PICSTART® PLUS MECHATRONICS GETTING STARTED GUIDE

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Chapter 1. Getting Started with the PICSTART® Plus Mechatronics Kit

1.0 Introduction

Microchip strives to give engineers new tools and choices for implementing state-of-the-art control designs.Our minimal footprint microcontrollers are a case in point. There is a great deal of smarts packed into a tiny space in our 8-bit microcontrollers. As your designs grow in complexity, the code you write (later) can be easily transitioned to larger Microchip microcontrollers with more peripheral resources.

In order to help you get acquainted with the benefits gained by incorporating a microcontroller into your design, we will guide you through the steps in setting up your system, writing a short program, and programming your first PICmicro® MCU.

To get started, you need to install Microchip's MPLAB™ Integrated Development Environment (IDE). PICSTART® Plus Mechatronics Kit, and MPLAB IDE, which is supplied on CD-ROM.

NOTES:

Chapter 2. Installing MPLAB-v4.11 or Later

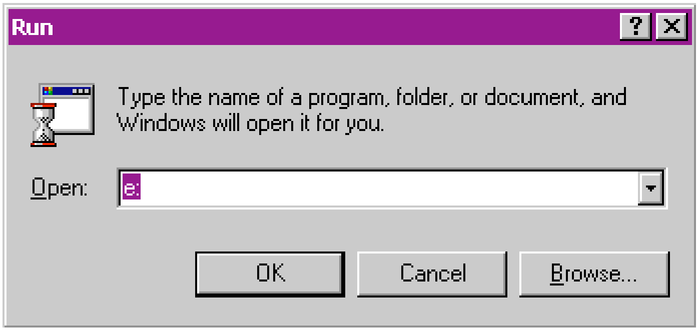
2.1 CD-ROM Installation

1. Insert the MPLAB CD-ROM into your CD-ROM drive.

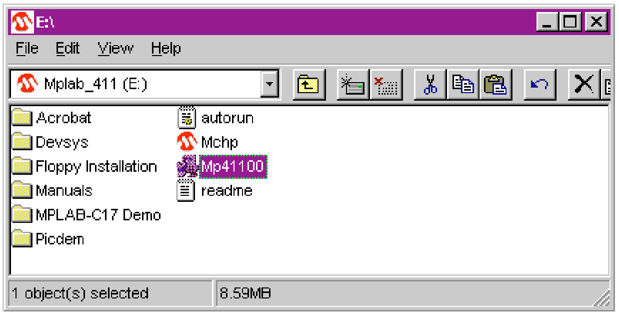
   If running Windows®95 with autoplay turned on, MPLAB™ should begin loading. If running Windows95 with autoplay turned off click the **START** button in the lower left-hand corner of your computer screen.

   If running Windows 3.1x, select **File** from the tool bar.

2. Select **Run…** from the menu to bring up the dialog box. Enter the drive letter for your CD-ROM (i.e., e:) Click **OK**.


Run
Type the name of a program, folder, or document, and Windows will open it for you.
Open: e:
OK
Cancel
Browse...

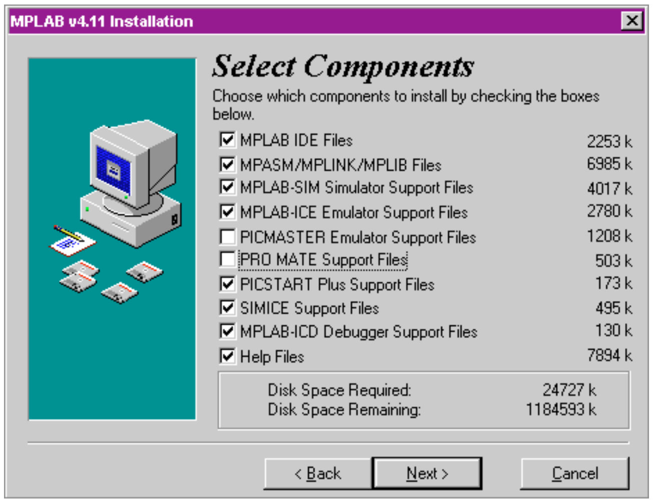
Click the **Browse** button. To begin the installation program, double-click on Mp41100.



Note: Future versions of MPLAB will have higher revisions numbers (for example: Mp50000) and are available from Microchip's web site at www.microchip.com under "Development Tools."

3. The *Select Components* window enables you to select which components you want to install. A checkmark in the box will install the component. For this application using the PICSTART® Plus programmer, select the components as shown in the diagram. Click **Next** to proceed or **Back** to edit the previous selections.

   Note: If you have a PICMASTER® emulator or a PRO MATE® programmer, you will want to select the components for them as well.



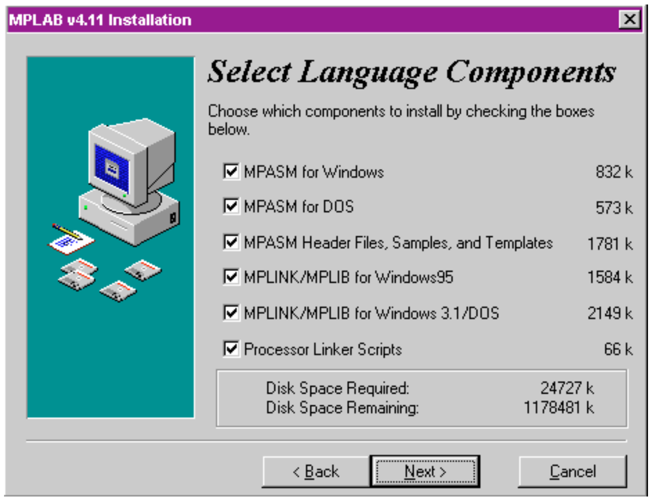
Select Components

Choose which components to install by checking the boxes below.

☑ MPLAB IDE Files	2253 k
☑ MPASM/MPLINK/MPLIB Files	6985 k
☑ MPLAB-SIM Simulator Support Files	4017 k
☑ MPLAB-ICE Emulator Support Files	2780 k
☐ PICMASTER Emulator Support Files	1208 k
☐ PRO MATE Support Files	503 k
☑ PICSTART Plus Support Files	173 k
☑ SIMICE Support Files	495 k
☑ MPLAB-ICD Debugger Support Files	130 k
☑ Help Files	7894 k

Disk Space Required: 24727 k
Disk Space Remaining: 1184593 k

4. The *Select Language Components* window enables you to select the Language Components for developing applications in MPLAB. For our purposes the default setting of all selected components is desired. Click **Next** to proceed or **Back** to edit the previous selections.



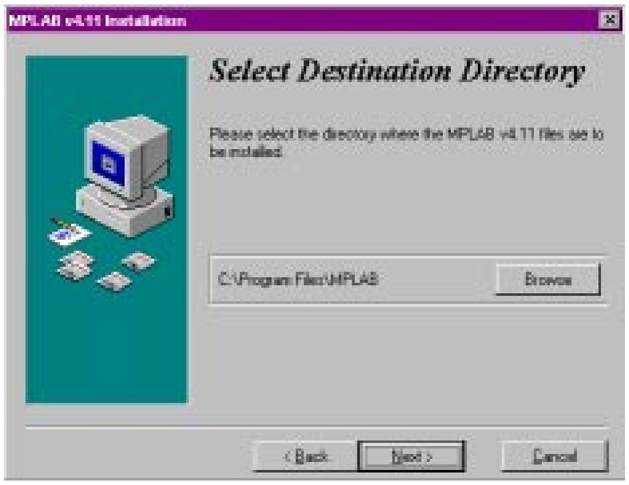
Select Language Components

Choose which components to install by checking the boxes below.

☑ MPASM for Windows	832 k
☑ MPASM for DOS	573 k
☑ MPASM Header Files, Samples, and Templates	1781 k
☑ MPLINK/MPLIB for Windows95	1584 k
☑ MPLINK/MPLIB for Windows 3.1/DOS	2149 k
☑ Processor Linker Scripts	66 k

Disk Space Required: 24727 k
Disk Space Remaining: 1178481 k

5. Next, select the destination directory where you want to install the MPLAB IDE files. The default setting is C:\Program Files\ MPLAB. Click **Next** to proceed or **Back** to edit the previous selections.



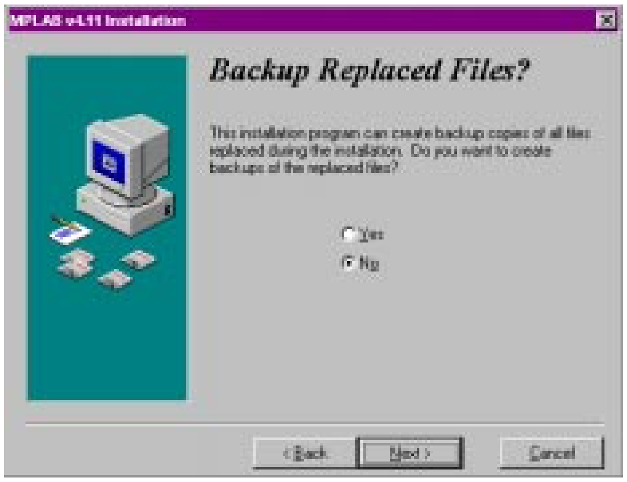
MPLAB v4.11 Installation

Select Destination Directory

Please select the directory where the MPLAB v4.11 files are to be installed.

C:\Program Files\MPLAB

6. You can instruct the installation to save any files replaced by the installation process. Use this option if you want to create backups of the originals. The default setting is No. Click **Next** to proceed or **Back** to edit the previous selections.



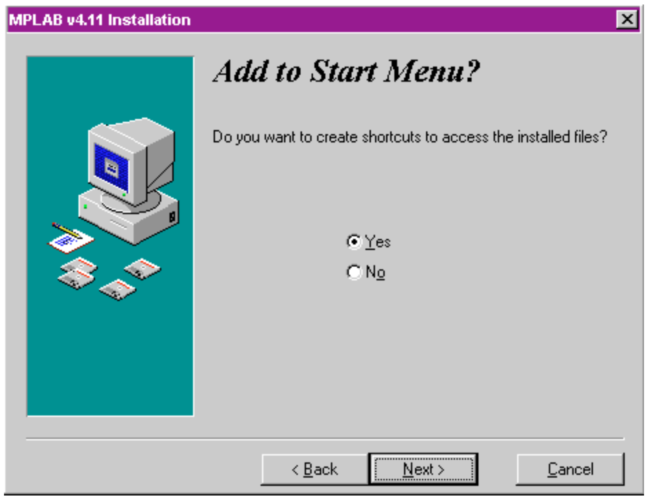
MPLAB v4.11 Installation

Backup Replaced Files?

This installation program can create backup copies of all files replaced during the installation. Do you want to create backups of the replaced files?

Yes [✓ No]

7. This window instructs the installation to add MPLAB to the Start Menu. The default setting is Yes. Click **Next** to proceed or **Back** to edit the previous selections.

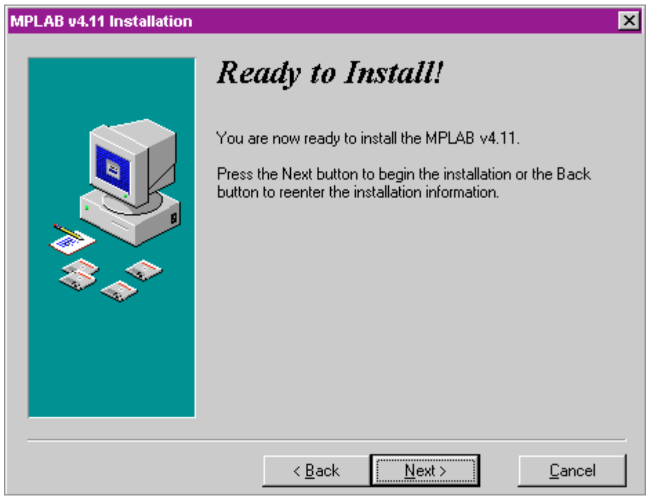

MPLAB v4.11 Installation

Add to Start Menu?

Do you want to create shortcuts to access the installed files?

[✓ Yes] No

8. You are ready to start the installation process, click **Next** to proceed or **Back** to edit the previous selections.

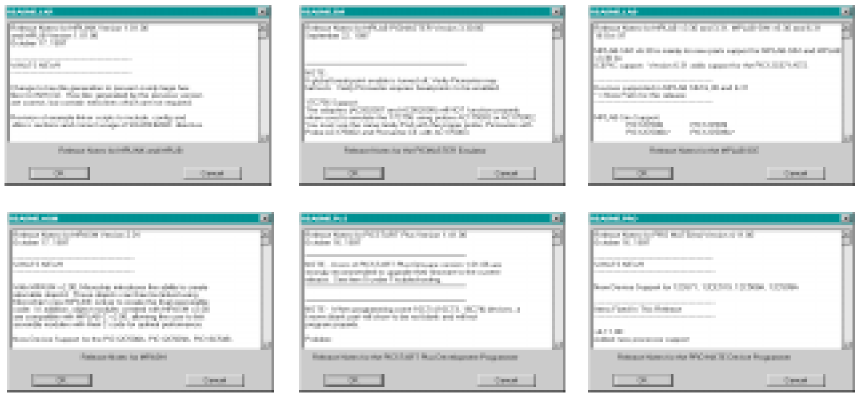

MPLAB v4.11 Installation

Ready to Install!

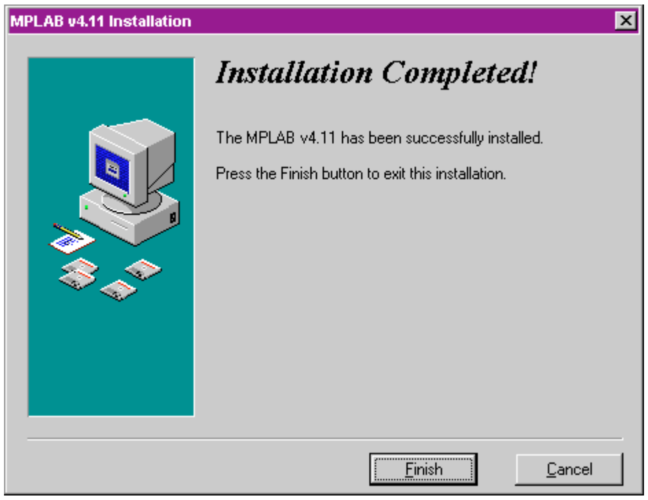
You are now ready to install the MPLAB v4.11.

Press the Next button to begin the installation or the Back button to reenter the installation information.

9. Several Read Me files will be shown sequentially to give you the latest information about the development tools. You may want to read through these prior to clicking **OK** to proceed. They will look like this:



10. The installation is now complete. Click on **Finish**.



Installation Completed!

The MPLAB v4.11 has been successfully installed.

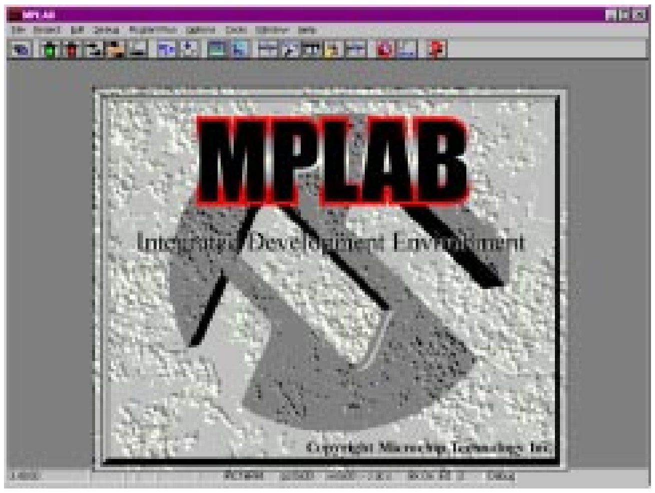
Press the Finish button to exit this installation.

2.2 Connecting the PICSTART Plus Programmer

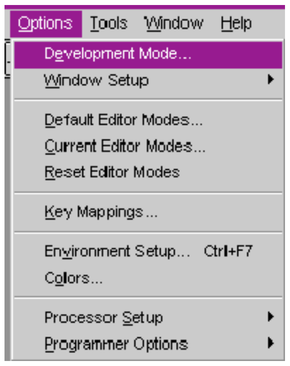
Turn off your computer. Connect the serial cable and PICSTART Plus Development Programmer to an available COM Port on the back of your computer. Connect the power supply to the PICSTART Plus and plug it in. The power light should be illuminated on the PICSTART Plus.

Turn on the computer.

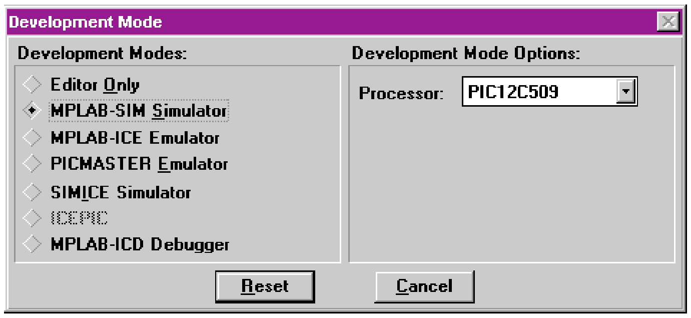
1. Start MPLAB by clicking on the MPLAB icon in the Microchip MPLAB program group. The MPLAB IDE is now running and you are ready to create a project.


MPLAB
Integrated Development Environment
Copyright Microchip Technology Inc.

2. Since we will be using the PIC12C509 in our design, let's set up the development mode. From the pull-down menu, select *Options>Development Mode.*



3. Select **MPLAB-SIM Simulator** by highlighting the diamond shaped box, then click on the drop-down arrow and choose PIC12C509 as the processor. Then click the **Reset** button at the bottom of the screen.



Development Mode

Development Modes:
- Editor Only
- MPLAB-SIM Simulator (selected)
- MPLAB-ICE Emulator
- PICMASTER Emulator
- SIMICE Simulator
- ICEPIC
- MPLAB-ICD Debugger

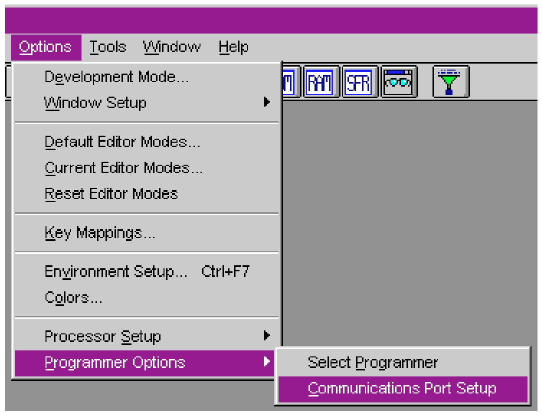
Development Mode Options:

Processor: PIC12C509

Reset | Cancel

4. Next you will set up the PICSTART Plus programmer. From the pull-down menu, select *Options>ProgrammerOptions>Select Programmer> PICSTART Plus*.
5. Now setup the COM port. From the pull-down menu, select *Options>Programmer Options>Communications Port Setup*. Select the COM port you have connected to the PICSTART programmer.

Note: If you experience any problems with PICSTART Plus communications, please see Appendix C.

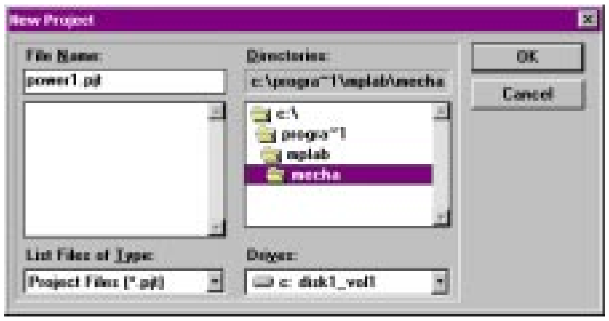


NOTES:

Chapter 3. Your First Project for Version 4.11 or Later

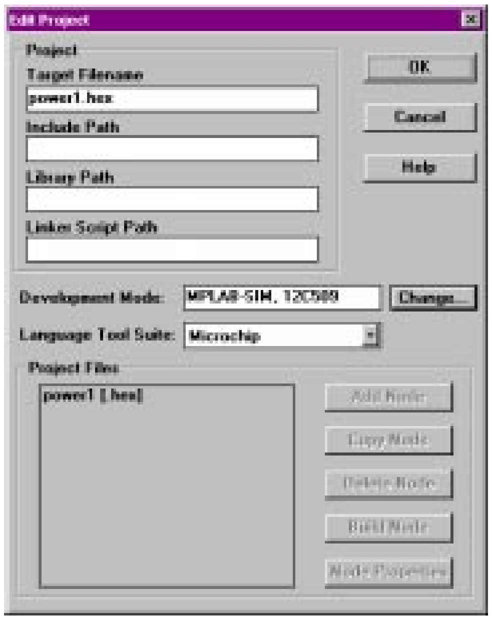
To begin the process of developing your application, you must first create a project. Projects keep track of the windows you have open and the files associated with your design. This enables you to pick up where you left off each time you begin working.

1. Using Windows Explorer, create a project directory for this tutorial called “MECHA” under the MPLAB directory
2. Select _Project>New Project…_ from the pull-down menu.
3. A *New Project* window appears. Type power1.pjt as your project name and click **OK**. Select “mecha” under the MPLAB directory, and click **OK**.



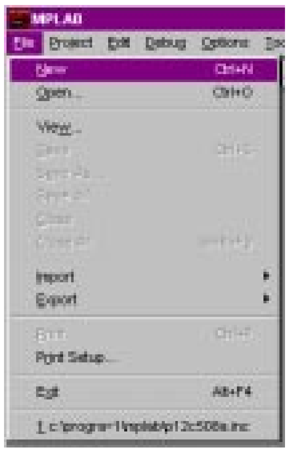
File Name: power1.pjt
Directories: c:\progra~1\mplab\mecha
c:\
progra~1
mplab
mecha
List Files of Type: Project Files (*.pjt)
Drives: c: disk1_vol1

4. The *Edit Project* window appears, click **OK**

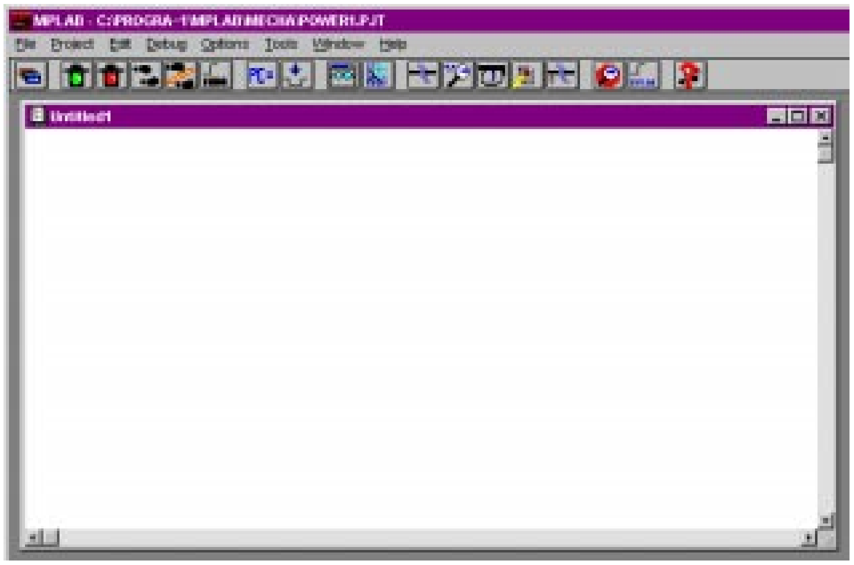


Project
Target Filename: power1.hex
Include Path:
Library Path:
Linker Script Path:
Development Mode: MPLAB-SIM, 12C509
Language Tool Suite: Microchip
Project Files: power1 [.hex]

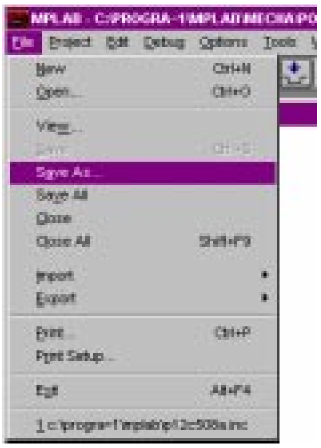
5. Next, select *File>New* from the pull-down menu.



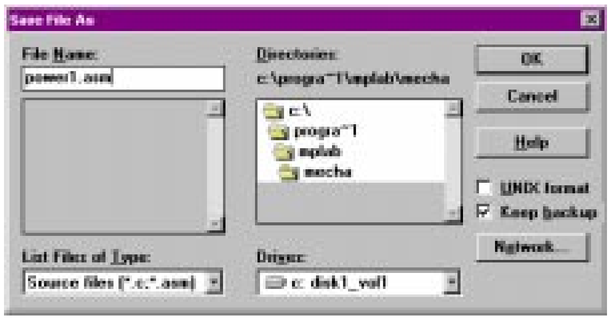
6. A new blank source page will open. The default file name will be similar to Untitled1.


MPLAB - C:\PROGRA~1\MPLAB\MECHA\POWER1.PJT
File Project Edit Debug Options Tools Window Help
Untitled1

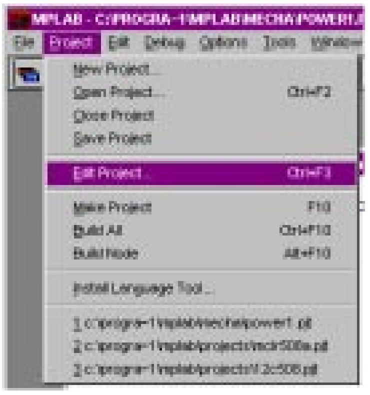
7. Again, select *File>Save* As from the pull-down menu.



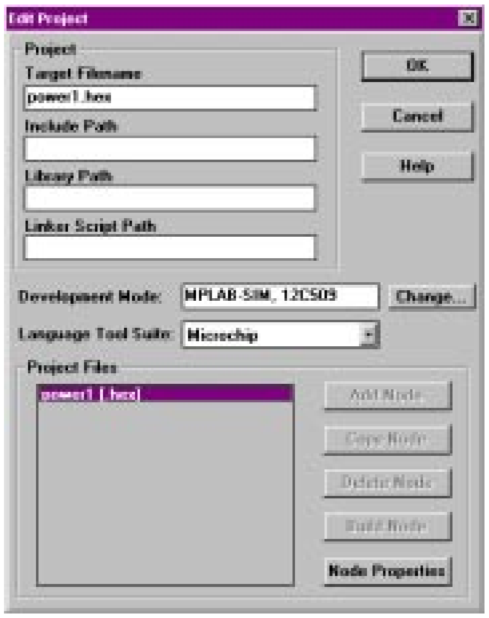
8. The *Save File As* window appears. Make sure your are saving this file into your project directory. Type in power1.asm as the File Name and click **OK**.



9. Next, you will add the source file to your project. Select *Project>Edit Project* from the pull-down menu.

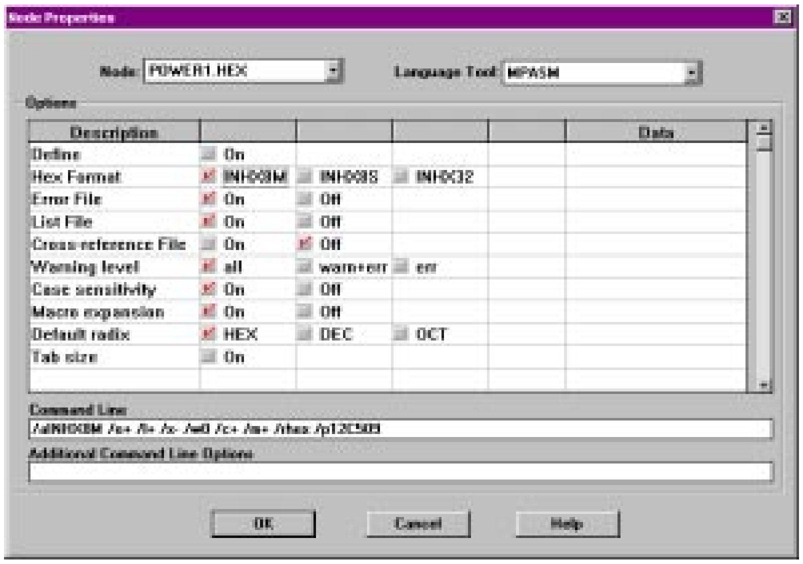

MPLAB - C:\PROGRA~1\MPLAB\MECHA\POWER1.
File Project Edit Debug Options Tools Window
New Project...
Open Project... Ctrl+F2
Close Project
Save Project
Edit Project... Ctrl+F3
Make Project F10
Build All Ctrl+F10
Build Node Alt+F10
Install Language Tool...
1 c:\progra~1\mplab\mecha\power1.pjt
2 c:\progra~1\mplab\projects\mclr508a.pjt
3 c:\progra~1\mplab\projects\12c508.pjt

10. Click on the project filename power1.hex and press the **Node Properties** button.



Target Filename: power1.hex
Include Path:
Library Path:
Linker Script Path:
Development Mode: MPLAB-SIM, 12C509
Language Tool Suite: Microchip
Project Files: power1 [.hex]

11. The *Node Properties* window opens. Make sure the check boxes are selected as shown below and click **OK**.
    - NODE should be set to POWER1.HEX
    - Language Tool should be set to MPASM
    - Hex Format should be set to INHX8M
    - Error File and List File should be set to On
    - Case sensitivity, Macro expansion, and Default radix can be set to the user's preference. For this tutorial configure them as shown.



Node: POWER1.HEX Language Tool: MPASM

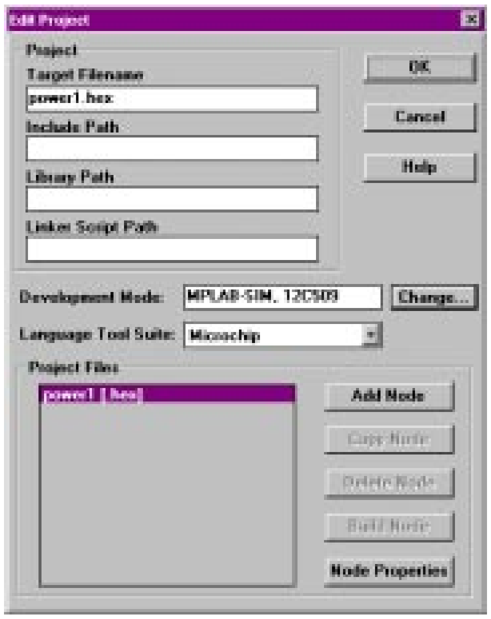
Options

Description					Data
Define	☐ On				
Hex Format	✓ INHX8M	☐ INHX8S	☐ INHX32		
Error File	✓ On	☐ Off			
List File	✓ On	☐ Off			
Cross-reference File	☐ On	✓ Off			
Warning level	✓ all	☐ warn+err	☐ err		
Case sensitivity	✓ On	☐ Off			
Macro expansion	✓ On	☐ Off			
Default radix	✓ HEX	☐ DEC	☐ OCT		
Tab size	☐ On				

Command Line
/aINHX8M /x+ /l+ /x- /w0 /c+ /m+ /rhex /p12C509

Additional Command Line Options

12. Next, click on the **Add Node** button to display the *Add Node* window.

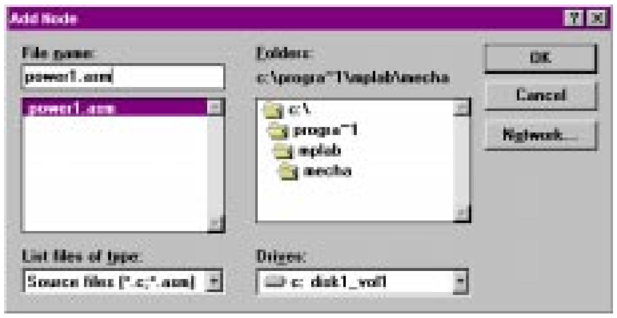


Project
Target Filename: power1.hex
Include Path:
Library Path:
Linker Script Path:

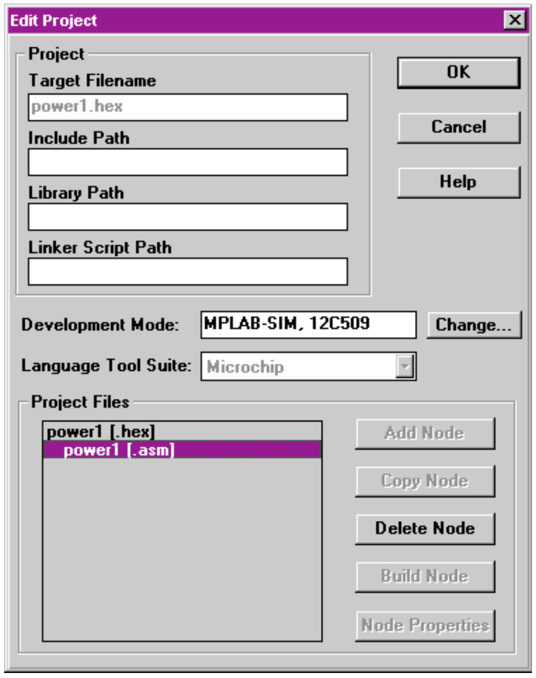
Development Mode: MPLAB-SIM, 12C509
Language Tool Suite: Microchip

Project Files
power1 [.hex]

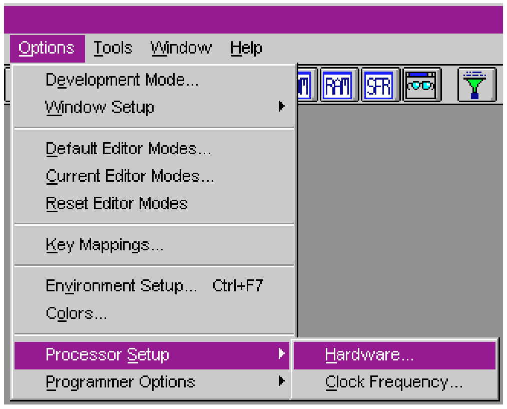
13. Select your source file or type **power1.asm** as the File Name, and then click **OK**.



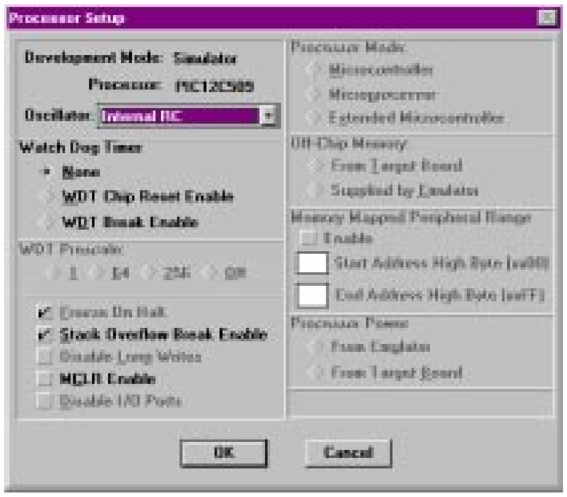
14. You should now see that both nodes are shown in the *Project* window, as shown below. Click the **OK** button to save your changes.



15. Now we will set up the *Hardware* configurations. From the pull-down menu, select _Options>Processor Setup>Hardware_.



16. The *Processor Setup* window opens. make sure to select options shown below.
    - Select **Oscillator**: Internal RC.
    - **WatchDog Timer** should be none.
    - **Stack Overflow Break Enabled** should be selected.
    - **MCLR Enable** is disabled.



Processor Setup

Development Mode: Simulator
Processor: PIC12C505
Oscillator: Internal RC

Watch Dog Timer
- ● None
- ○ WDT Chip Reset Enable
- ○ WDT Break Enable

WDT Prescale: ○ 1 ○ 64 ○ 256 ○ Off

- ✓ Freeze On Halt
- ✓ Stack Overflow Break Enable
- ☐ Disable Long Writes
- ☐ MCLR Enable
- ☐ Disable I/O Ports

Processor Mode
- ○ Microcontroller
- ○ Microprocessor
- ○ Extended Microcontroller

Off-Chip Memory
- ○ From Target Board
- ○ Supplied by Emulator

Memory Mapped Peripheral Range
- ☐ Enable
- Start Address High Byte (xx00)
- End Address High Byte (xxFF)

Processor Power
- ○ From Emulator
- ○ From Target Board

OK Cancel

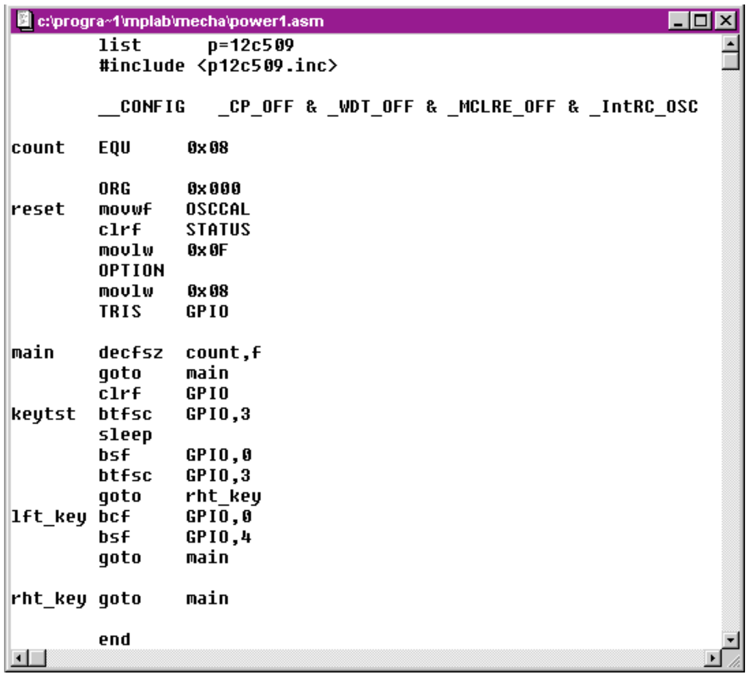
Your project has now been created. If at any time you wish to stop working on your project, you can close all windows by selecting _Project>Close Project_ and answer YES to save it. The next time you are ready to continue working, you can select _Project>Open Project_ and pick up where you left off.

3.1 Entering Source Code

You are now ready to edit the file power1.asm to create the code needed for your application. (See Chapter 4 for a detailed line-by-line explanation of the source code.)

1. Type the following lines of text in the *power1.asm* window:

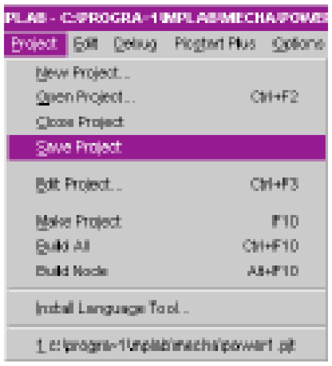
   Note: This code is case sensitive, pay special attention to lower and upper case characters. In line 3, the text: `__CONFIG` has 2 underscore characters in it.



c:\progra~1\mplab\mecha\power1.asm

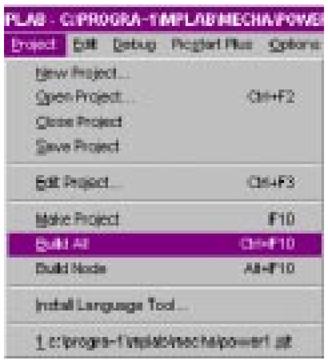
```
        list     p=12c509
        #include <p12c509.inc>

        __CONFIG   _CP_OFF & _WDT_OFF & _MCLRE_OFF & _IntRC_OSC

count   EQU     0x08

        ORG     0x000
reset   movwf   OSCCAL
        clrf    STATUS
        movlw   0x0F
        OPTION
        movlw   0x08
        TRIS    GPIO

main    decfsz  count,f
        goto    main
        clrf    GPIO
keytst  btfsc   GPIO,3
        sleep
        bsf     GPIO,0
        btfsc   GPIO,3
        goto    rht_key
lft_key bcf     GPIO,0
        bsf     GPIO,4
        goto    main

rht_key goto    main

        end
```

2. After entering the source code, select *Project>Save Project* from the pull-down menu to save your project.



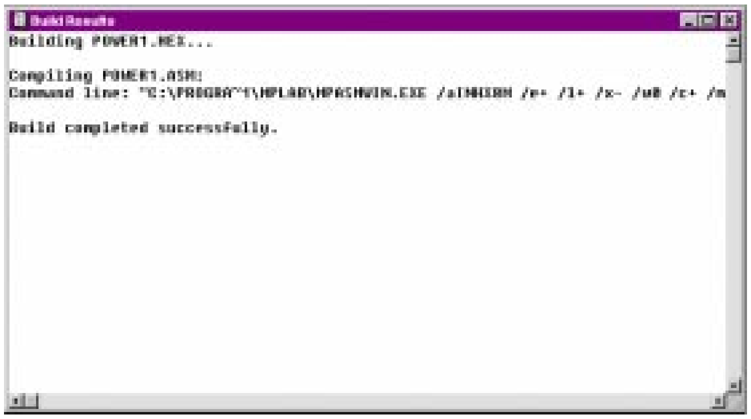
3.2 Building the Project Code

1. You are now ready to build the project. This will produce the hex file that will be used to program the PIC12C509 microcontroller part. A hex file is created from the source file you have written and has the same name as the source file except for the file extension which ends in .hex. The hex file contains the program as it would be written to the PICmicro MCU, in a numeric format. Select *Project>Build All* from the pull-down menu.



2. If everything has been performed correctly, a *Build Results* window appears indicating "Build Completed Successfully." Click close to continue. The close button is the "X" box in the upper right had corner of the window.

   Note: If the *Build Results* window indicates errors, recheck your source code in the source file.



```
Building POWER1.HEX...

Compiling POWER1.ASM:
Command line: "C:\PROGRA~1\MPLAB\MPASMWIN.EXE /aINHX8M /e+ /l+ /x- /u0 /c+ /m

Build completed successfully.
```

3. Click **OK** to continue.

NOTES:

Chapter 4. About the Demonstration Program

The program was designed to work with the "Pong Board." The schematic is located in Appendix A.2. There are two LEDs and two switches. Pressing a switch (left or right) lights the corresponding left or right LED.

To better understand the source code program and how it works, below is a line-by-line evaluation of the program. The first three lines of the program (`list`, `#include` and `__config`) and the last line (`end`) are directives. That is, they are instructions to the assembler about how to create this program, but do not actually translate to program instructions.

```
list   p=12c509
```

This tells the assembler that this program is for the processor PIC12C509.

```
#include <p12c509.inc.>
```

The `#include` directive tells the assembler to bring in another file at this point. The file named p12c509.inc is provided by Microchip to simplify the naming and assigning of special function registers, flag bits, and configuration word bits.

```
__CONFIG _CP_OFF & _WDT_OFF & _MCLRE_OFF  & _IntRC_OSC
```

The `__CONFIG` directive tells the assembler how you want the configuration word programmed. (See the PIC12C5XX datasheet (DS40139) for details on the configuration word.) All Microchip PICmicro MCUs have a configuration word where certain features of the part are enabled or disabled. (there are two "underscore" characters preceding the word `CONFIG`, all other occurrences are single underscores) By ANDing the options you have chosen together (with the & character) you construct the desired configuration word. In this case, we have chosen to turn code protect off, the Watchdog Timer off, External Master Clear Pin off, and set the oscillator to internal RC.

```
end
```

The `end` statement tells the assembler that it has reached the end of the assembly file. All program code is placed before the end statement.

```
count EQU 0x08
```

The `equ` directive, called "equate" assigns a value to a label. Here, we are saying that we would like the number 8 to be used in place of the label `count` in our program. The label `count` is used as a variable in our example, and is located at address `0x08` in data memory. Note that `count` is a label, and as such should be placed at the left-most column of the page.

4.1 Instruction Definition

To help you better understand the program, we have defined the instructions used in it below. A program flow chart describing the program execution is located on page 28. A more thorough explanation of these instructions, and the many features of this part, can be found in the PIC12C5XX datasheet (DS40139).

> **Note:** Many PICmicro instructions can access two registers at the same time. One register is W, the working register, the other register is the data address of your choice.

`movwf GPIO`

MOVe W to F. Copies the value currently stored in the W register to the register selected – in this example, the GPIO (General Purpose Input/Output) register.

`movlw 0x0F`

MOVe Literal to W. Moves a value into W. In this case, the hexadecimal value `F` is copied.

`OPTION`

Copies the current value of W into the `OPTION` register. For instance, “wake up on port change” and “weak pullups” are enabled in the option register for this part. (Port pullups cause the inputs to default to one if no other input is present on the pin).

`TRIS GPIO`

Copies the current value in W to the direction register (or TRIS register) of the port signified. In this case the port GPIO is being configured. A '1' configures a pin to an input for reading values in, and a '0' configures a pin as an output for writing values out.

`decfsz count,f`

DECrement F Skip if Zero. The `decfsz` instruction decrements the value in the register designated (in this case `count`). If the result is zero, the instruction immediately following this instruction is skipped (usually a goto instruction which branches back up and causes the value to be continuously decremented until it reaches zero). The result of the decrement can be placed back into the file register designated by ending the instruction with `f` (as is done here) or it can be copied into the W register by putting a `w` at the end of the instruction instead of `f`. Note that if neither `f` nor `w` is written, the assembler defaults to `f`.

`goto main`

This instruction causes the program to branch to the location indicated. You will notice that in this example program several 'labels' have been placed in the left column, such as `main`. Labels make it easier to read a program and see where it is branching. You should note that ONLY labels are placed in the left-most column. Anything else placed to the left edge will be mistakenly interpreted as a label, which could cause errors in your program.

```
clrf STATUS
```

```
clrf GPIO
```

CLeaR F. The `clrf` instruction simply clears, or zeros, the contents of the designated register. Here, the STATUS register is being initialized to zero. In this case, the register GPIO is cleared, which has the effect of making all I/O pins configured as outputs, to output a zero. See the PIC12C5XX datasheet (DS40139) for details on the `STATUS` register.

```
btfsc GPIO,3
```

Bit Test F, Skip if Cleared. This instruction tests a bit and skips the next instruction if the bit is zero. In this case we are testing bit 3 (which corresponds to pin 4) of the GPIO port to see if a switch has been pressed. The instruction immediately after the bit test is usually a `GOTO` that branches to another part of the program.

```
sleep
```

The `sleep` instruction causes the clock oscillator to stop and all program execution to be halted. This puts the part into a low power mode. Several features can be enabled which will wake the processor from sleep. These include, a timed wake-up period, called the WDT, or WatchDog Timer; a reset, caused by a low input on the MCLR pin, if MCLRE is enabled; and finally a change on a port pin (like a key press) if wake-up on pin change is enabled. In this example only wake-up on pin change is enabled.

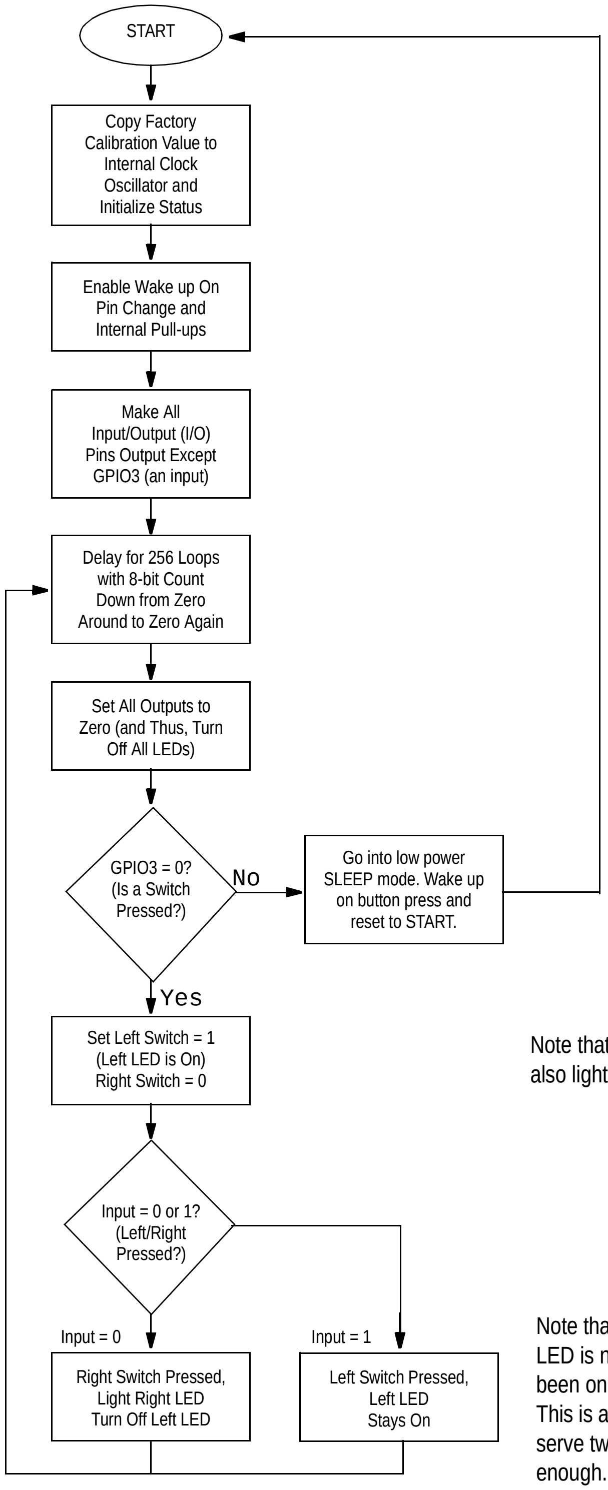
```
bcf GPIO,0
```

```
bsf GPIO,4
```

These instructions clear a bit (`bcf`) or set a bit (`bsf`). Clearing a bit on an output pin causes the output on the pin to go low, or 0V. Setting a bit causes it to go high, or to 5V in a 5V system. In our example, setting a bit turns on an LED connected to the associated pin. In this example, we are clearing bit 0 and setting bit 4 of the GPIO.

4.2 Flowchart of the Program Code

```
reset    movwf  OSCCAL
         clrf   STATUS

         movlw  0x0F
         OPTION

         movlw  0x08
         TRIS   GPIO

main     decfsz count,f
         goto   main

         clrf   GPIO

keytst   btfsc  GPIO,3
         SLEEP

         bsf    GPIO,0

         btfsc  GPIO,3
         goto   rht_key

lft_key  bcf    GPIO,0
         bsf    GPIO,4
         goto   main

rht_key  got    main
```


START
Copy Factory Calibration Value to Internal Clock Oscillator and Initialize Status
Enable Wake up On Pin Change and Internal Pull-ups
Make All Input/Output (I/O) Pins Output Except GPIO3 (an input)
Delay for 256 Loops with 8-bit Count Down from Zero Around to Zero Again
Set All Outputs to Zero (and Thus, Turn Off All LEDs)
GPIO3 = 0? (Is a Switch Pressed?)
No
Go into low power SLEEP mode. Wake up on button press and reset to START.
Yes
Set Left Switch = 1 (Left LED is On) Right Switch = 0
Input = 0 or 1? (Left/Right Pressed?)
Input = 0
Input = 1
Right Switch Pressed, Light Right LED Turn Off Left LED
Left Switch Pressed, Left LED Stays On

Note that setting the left switch to 1 also lights the left LED temporarily.

Note that if the right LED is lit, the left LED is now turned off. It will not have been on long enough to be visible. This is an example of how one pin can serve two functions if the part is fast enough.

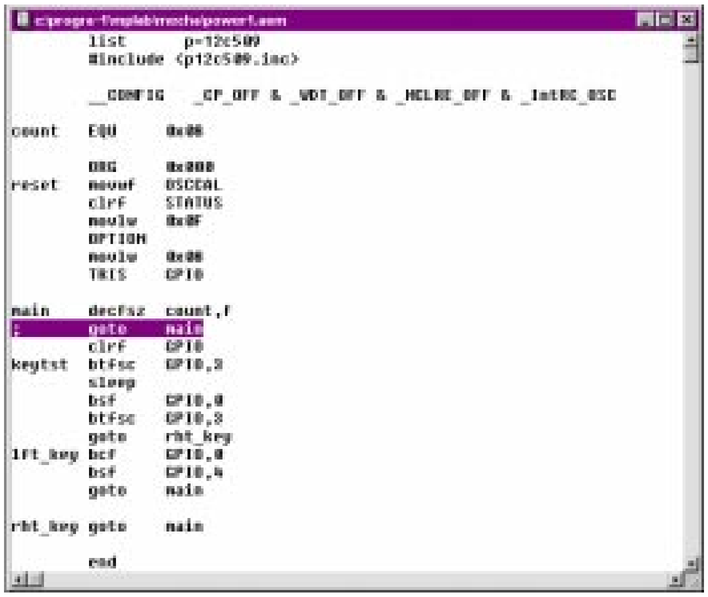
Chapter 5. Demonstrating the Simulator

5.1 Asynchronous Stimulus

The simulator is designed to step through your code to view registers, stimulate pins, etc., for debugging code. Asynchronous Stimulus controls the pin state to either be a high (1) or low (0).

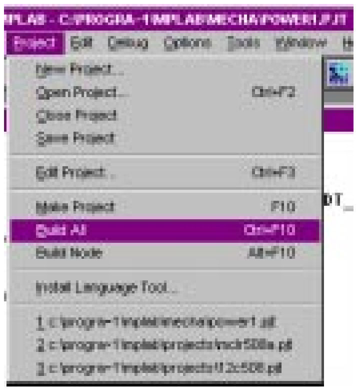
1. To demonstrate this, you must first modify your code. Add a semicolon (;) to line 17 as shown. The semicolon comments out the `goto main` statement, which allows skipping the delay loop. We are going to step through the code manually for demonstration purposes and do not wish to waste time stepping through 256 cycles of delay loop.

   Note: After this demonstration, remove the semicolon and reassemble the file or the proper delay will not occur for a programmed part.



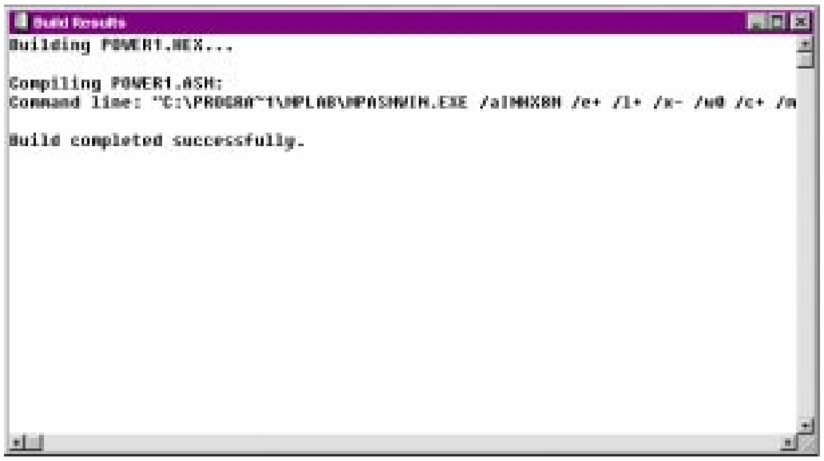
```
        list      p=12c509
        #include <p12c509.inc>

        __CONFIG   _CP_OFF & _WDT_OFF & _MCLRE_OFF & _IntRC_OSC

count   EQU      0x08

        ORG      0x000
reset   movwf    OSCCAL
        clrf     STATUS
        movlw    0x0F
        OPTION
        movlw    0x08
        TRIS     GPIO

main    decfsz   count,f
;       goto     main
        clrf     GPIO
keytst  btfsc    GPIO,3
        sleep
        bsf      GPIO,0
        btfsc    GPIO,3
        goto     rht_key
lft_key bcf      GPIO,0
        bsf      GPIO,4
        goto     main

rht_key goto     main

        end
```

2. Next, from the pull-down menu, select *Project>Build All*.


MPLAB - C:\PROGRA~1\MPLAB\MECHA\POWER1.PJT
Project Edit Debug Options Tools Window
New Project...
Open Project... Ctrl+F2
Close Project
Save Project
Edit Project... Ctrl+F3
Make Project F10
Build All Ctrl+F10
Build Node Alt+F10
Install Language Tool...
1 c:\progra~1\mplab\mecha\power1.pjt
2 c:\progra~1\mplab\projects\mclr508a.pjt
3 c:\progra~1\mplab\projects\12c508.pjt

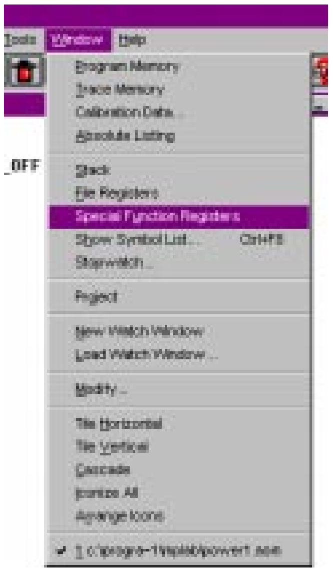
3. If everything has been performed correctly, a *Build Results* window will appear indicating "Build Completed Successfully." Click close to continue. The close button is the 'X' box in the upper right hand corner of the window.

   Note: If the *Build Results* window indicates errors, recheck your typing of the source code in the source file or, double-click on the error, and the cursor will be placed inside the source file near the location of the error.

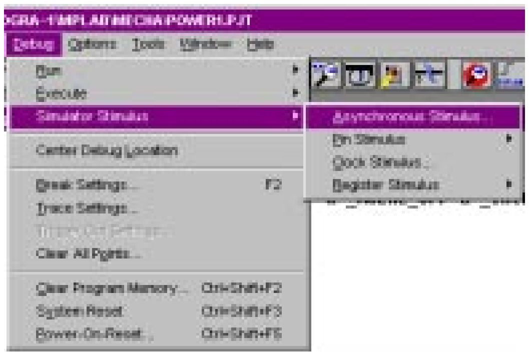


```
Building POWER1.HEX...

Compiling POWER1.ASM:
Command line: "C:\PROGRA~1\MPLAB\MPASMWIN.EXE /aINHX8M /e+ /l+ /x- /w0 /c+ /m

Build completed successfully.
```

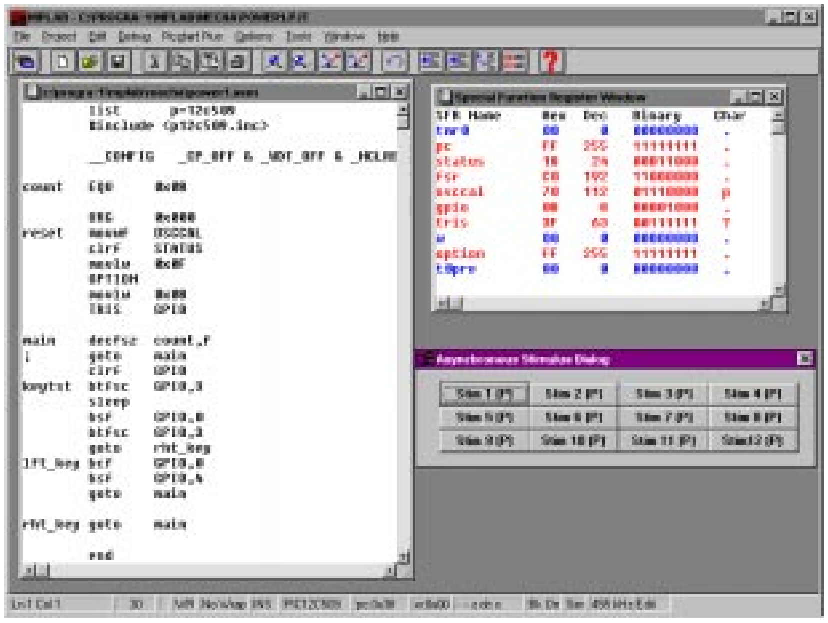
4. Next, from the pull-down menu, select *Window>Special Function Registers*. The *Special Function Register* window will now open. This window allows us to see the “GPIO” port.



5. Select *Debug>Simulator Stimulus>Asynchronous Stimulus* to open the *Asynchronous Stimulus* window. This window enables you to assign a pin to a button.



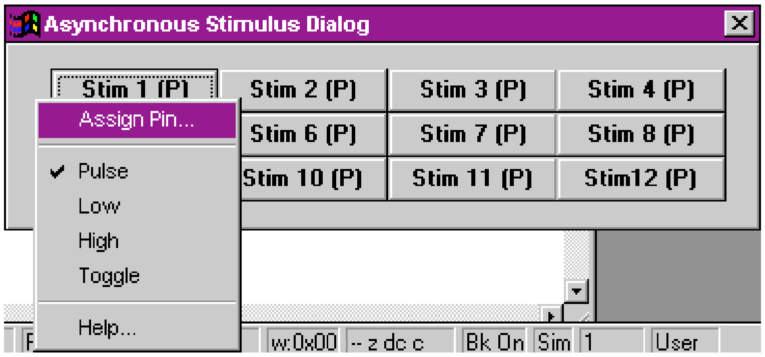
6. Move both of the *Special Function Registers* and *Asynchronous Stimulus Dialog* windows to allow you to view these along with your source file. MPLAB™ should look like the figure shown.



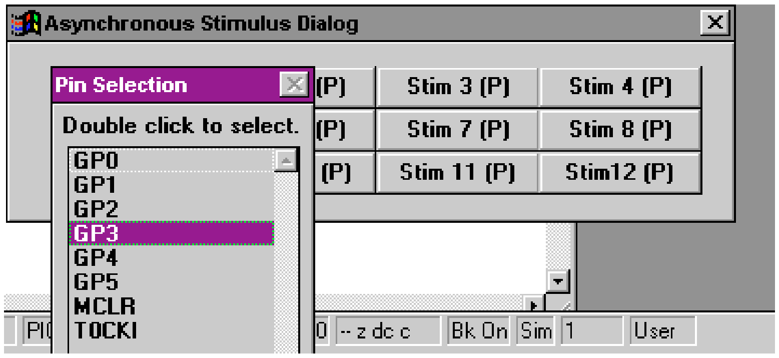
```
        list      p=12c508
        #include <p12c508.inc>

        __CONFIG    _CP_OFF & _WDT_OFF & _MCLR

count   EQU       0x08

        ORG       0x000
reset   movwf     OSCCAL
        clrf      STATUS
        movlw     0x0F
        OPTION
        movlw     0x08
        TRIS      GPIO

main    decfsz    count,f
;       goto      main
        clrf      GPIO
keytst  btfsc     GPIO,3
        sleep
        bsf       GPIO,0
        btfsc     GPIO,3
        goto      rht_key
lft_key bcf       GPIO,0
        bsf       GPIO,4
        goto      main

rht_key goto      main

        end
```

```
SFR Name    Hex   Dec   Binary     Char
tmr0        00      0   00000000    .
pc          FF    255   11111111    .
status      18     24   00011000    .
fsr         C0    192   11000000    .
osccal      70    112   01110000    p
gpio        08      8   00001000    .
tris        3F     63   00111111    ?
w           00      0   00000000    .
option      FF    255   11111111    .
t0pre       00      0   00000000    .
```

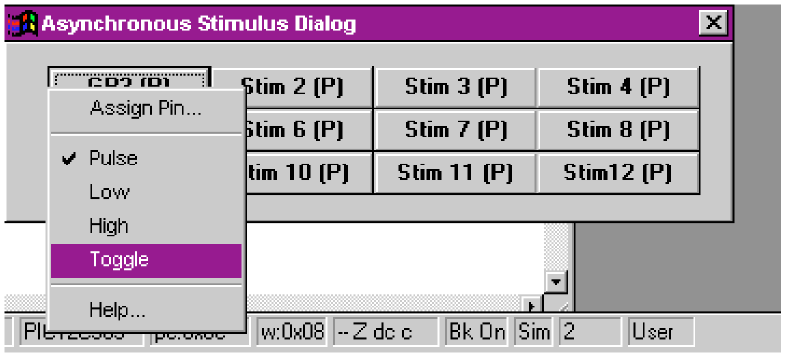
7. Next, move the mouse cursor to the *Asynchronous Stimulus Dialog* window. Right-mouse-click on the **Stim 1 (P)** button and select 'Assign Pin'.



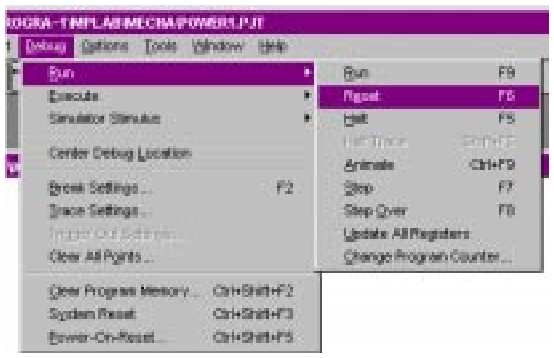
8. The *Pin Section* window will appear, double-left-lick on **GP3**. You have just assigned a pin to the button.



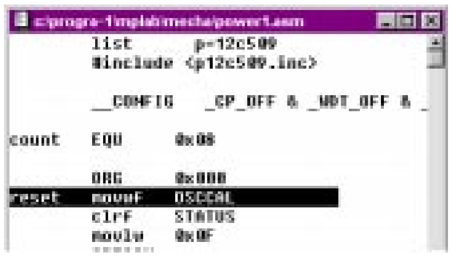
9. Now we want to assign an action to the botton. Move the mouse cursor over to the *Asynchronous Stimulus Dialog* window. Right-mouse-click on the **GP3 (P)** button and select 'Toggle'.



10. Next, we will start stepping through your code. If you feel you need to start over at any time, press the F6 (Reset) key on your keyboard. Press F6 (Reset) now or by *Debug>Run>Reset*.



You will notice the *Special Function Register* window has changed. The W register is highlighted in red indicating that the register has just been written to. Also in your “source file” a line is highlighted indicating that this is your next instruction to be operated. The highlighted text should be `reset movwf OSCCAL` as shown in the figure below.

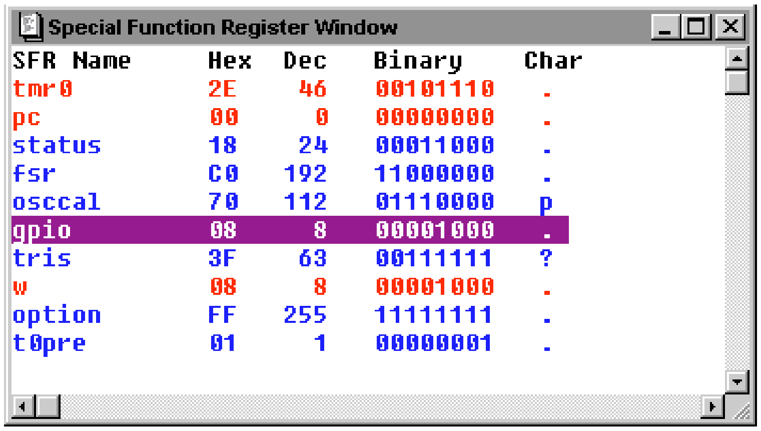

c:\progra~1\mplab\mecha\power1.asm

```
        list      p=12c509
        #include <p12c509.inc>

        __CONFIG   _CP_OFF & _WDT_OFF & _

count   EQU      0x08

        ORG      0x000
reset   movwf    OSCCAL
        clrf     STATUS
        movlw    0x0F
```

11. Take a look at the *Special Function Register* window, register `gpio`. You will notice under the `Binary` column, there are a series of 1's and 0's, like this:

```
00001000
```

The first number 0 on the right is GP0. The second number 0 from the right is GP1, and so on. You will notice GP3 is a number 1. This indicates that your **Asynchronous Stimulus** button is toggled high. If it is low (0), then pressing the button you assigned to this pin will toggle it high (1), after the next instruction is executed.

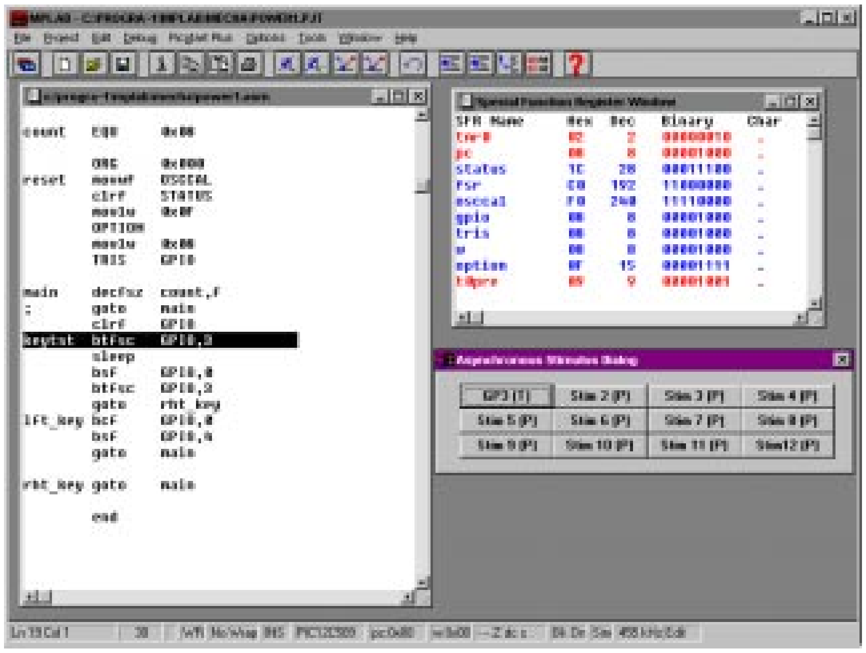


```
SFR Name       Hex   Dec   Binary     Char
tmr0           2E     46   00101110    .
pc             00      0   00000000    .
status         18     24   00011000    .
fsr            C0    192   11000000    .
osccal         70    112   01110000    p
gpio           08      8   00001000    .
tris           3F     63   00111111    ?
w              08      8   00001000    .
option         FF    255   11111111    .
t0pre          01      1   00000001    .
```

Now press the **GP3** button to toggle the pin to low. Click back on your *Source Code* window then press F7 (Step) or *Debug>Run>Step*. Take a look at your *Special Function Register* window. GP3 has changed from a 1 to a 0.

Note: To advance the *Source Code* and *Special Function Register* window, click on your source code window first, before pressing F7 (Step).

12. Next, step through your code by pressing F7 (Step) until you reach `keytst`. In your *Special Function Register* window, check your `GPIO` register. If GP3 is 1, it will step to the next line `sleep`. If GP3 is 0, it will skip `sleep` and go to `bsf` and keep running code.



```
count   EQU     0x08

        ORG     0x000
reset   movwf   OSCCAL
        clrf    STATUS
        movlw   0x0F
        OPTION
        movlw   0x08
        TRIS    GPIO

main    decfsz  count,F
;       goto    main
        clrf    GPIO
keytst  btfsc   GPIO,3
        sleep
        bsf     GPIO,0
        btfsc   GPIO,2
        goto    rht_key
lft_key bcf     GPIO,0
        bsf     GPIO,4
        goto    main

rht_key goto    main

        end
```

```
SFR Name       Hex   Dec   Binary     Char
tmr0           02      2   00000010    .
pc             08      8   00001000    .
status         1C     28   00011100    .
fsr            C0    192   11000000    .
osccal         F0    240   11110000    .
gpio           08      8   00001000    .
tris           08      8   00001000    .
w              08      8   00001000    .
option         0F     15   00001111    .
t0pre          09      9   00001001    .
```

```
Ln 19 Col 1   38   WR No Wrap INS   PIC12C509   pc:0x08   w:0x08
```

13. Now, press the GP3 button. GP3 again will change from a low (0) to a high (1).

Note: To advance the *Source Code* and *Special Function Register* windows, click on your source code window first, before pressing F7 (Step).

Now advance the code 10 times by pressing F7 (Step) ten times while viewing the *Source Code*. Notice how the code stops advancing, and the highlighted line stays at `bsf`. You are in `sleep` mode. See “Sleep Mode” and “Animate” on page 37 for more information.

Notice in the schematic, provided in Appendix A, that two different switches are being read by one pin. The simulator only simulates the function of one switch here.

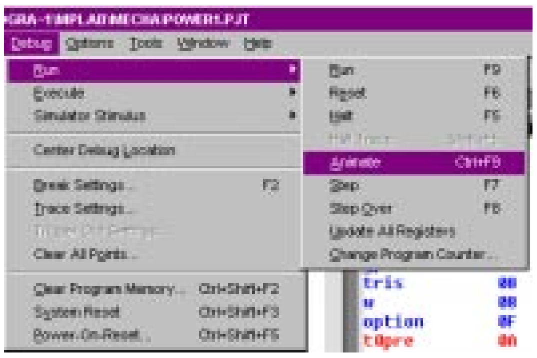
5.2 Sleep Mode

Sleep Mode is a power-down mode for conserving battery life. In this program, sleep mode will only happen when GP3 is a 1 or when neither switch is pressed. When sleep mode occurs, it will stop running code and keep incrementing `T0PRE`. You can press F7 (Step) indefinitely and there will not be any change except to `T0PRE`. To wake it from `sleep`, you have to toggle GP3 from a high (1) to a low (0). Once you do that, the code will return to the `reset` routine, and continue to run code as normal.

5.3 Animate

Another useful feature of the MPLAB Simulator is Animate. It allows the simulator to step through the code automatically without user interaction. You can view movement in code, changes in registers, etc.

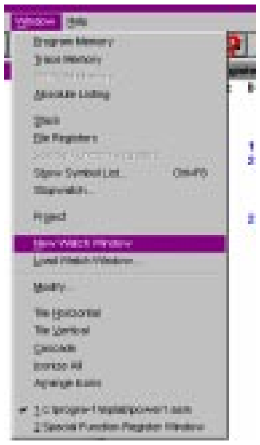
1. From the pull-down menu, select *Debug>Run>Animate*. The code will start animating or stepping through the code automatically. Press F5 (Halt) to end Animate.



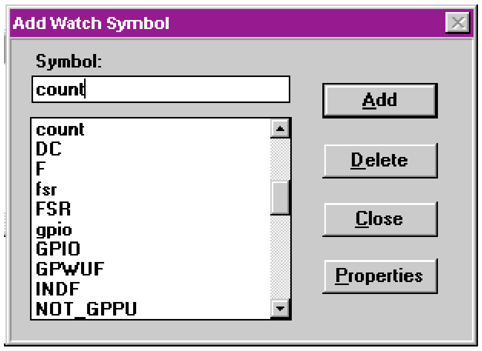
5.4 Watch Windows

Watch Windows are used to view registers that are declared at the beginning of the program, that are not already listed in the *Special Function Registe*r window. You may have noticed that there is one in the power1.asm code you wrote called “count.”

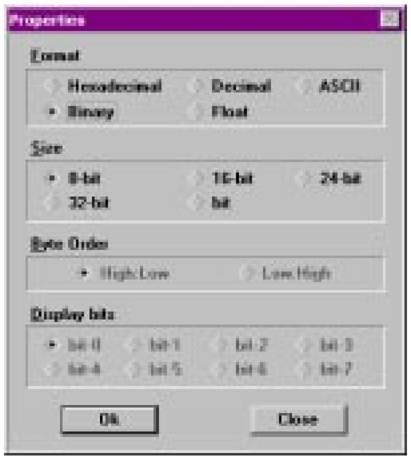
1. To create a Watch Window for “count,” select _Window>New Watch Window_.



2. The *Add Watch Symbol* window will appear. Type in or select “count,” and then click on **Properties** button.

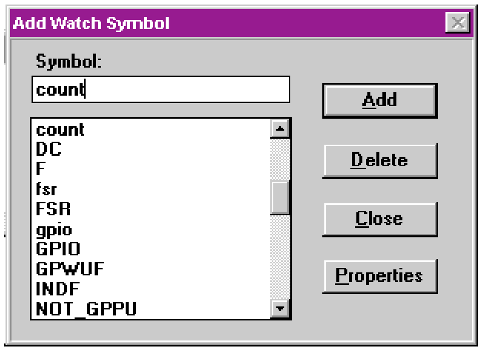


3. The *Properties* window will appear. Select *Binary* under *Format*, then click **OK**.



Format: [✓ Binary]; Size: [✓ 8-bit]; Byte Order: [✓ High:Low]; Display bits: [✓ bit 0]

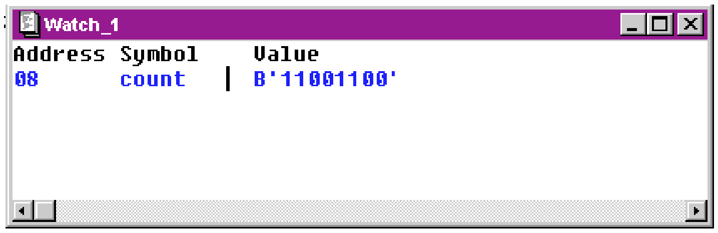
4. In the *Add Watch Symbol* window click on **Add** then **Close**.



Symbol:
count

count
DC
F
fsr
FSR
gpio
GPIO
GPWUF
INDF
NOT_GPPU

5. Your watch window should look like the figure below. Now stepping through your code using F7 (Step) will allow you to view that particular register without guessing what value is in it.

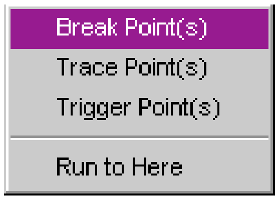


```
Address Symbol    Value
08      count    | B'11001100'
```

5.5 Break Points

Break points allows the program to stop in “Run” or “Animate” mode at a specified location in your source code for debugging.

1. To demonstrate, move your mouse cursor over to `OPTION` (line 12 in the source code). Right-mouse-click, and select Break Point(s).



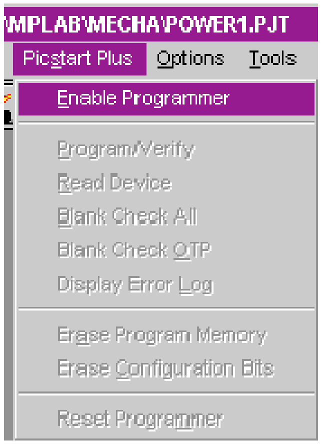
2. Next, press F6 (Reset), and then press F9 (Run). The code will run and stop at line 12 where `option` is. Now you can view your registers at that moment of the program.

Other important areas not covered here include “Trace,” “Arm Counter,” “Stimulus from a File,” and “Environment Setup.” These items are explained in the *MPLAB Users Guide*, the MPLAB Help Files or you can go to the web site www.microchip.com.

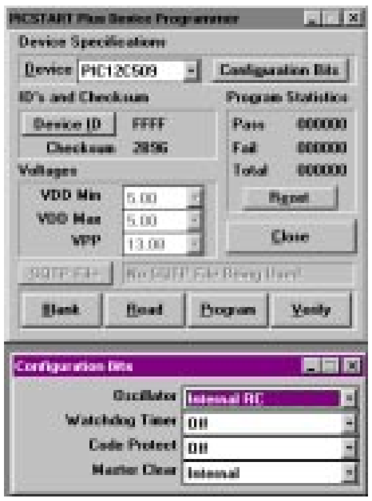
Chapter 6. Programming Your Code into the PIC12C509

1. You are now ready to program your code into the PIC12C509 microcontroller. First, make sure you have removed the semicolon (;) in front of the `goto main` statement, and then reassemble your code.

   Otherwise, this delay will be "commented out" and you will not see the LED light correctly. Select *PICSTART Plus>Enable Programmer* from the pull-down menu.



2. The *PICSTART Plus Device Programmer* window appears. Make sure that the PIC12C509 is selected. (If it is not, changing the processor may require you to close the project while the programmer resets. You can reopen the project after the correct device is selected.)



PICSTART Plus Device Programmer

Device Specifications

Device: PIC12C509

ID's and Checksum

Device ID: FFFF

Checksum: 2B96

Program Statistics

Pass: 000000

Fail: 000000

Total: 000000

Voltages

VDD Min: 5.00

VDD Max: 5.00

VPP: 13.00

Configuration Bits

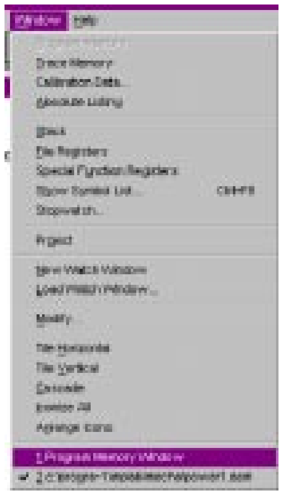
Oscillator: Internal RC

Watchdog Timer: Off

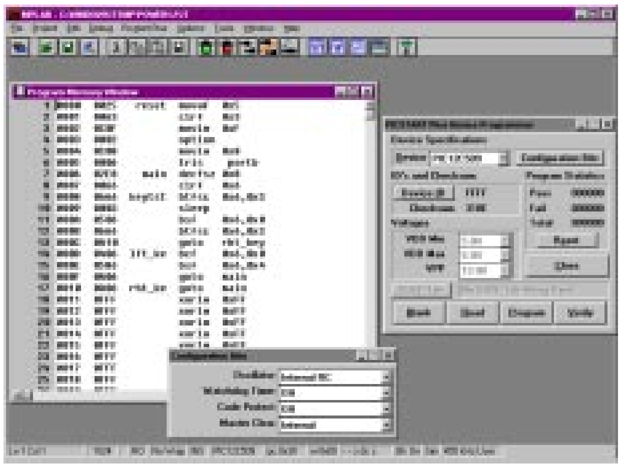
Code Protect: Off

Master Clear: Internal

3. Select *Window>Program Memory Window* from the pull-down menu to bring the *Program Memory Window* to the front of your desktop. If the window is not open, select *Program>Memory*. Your screen should look like this:



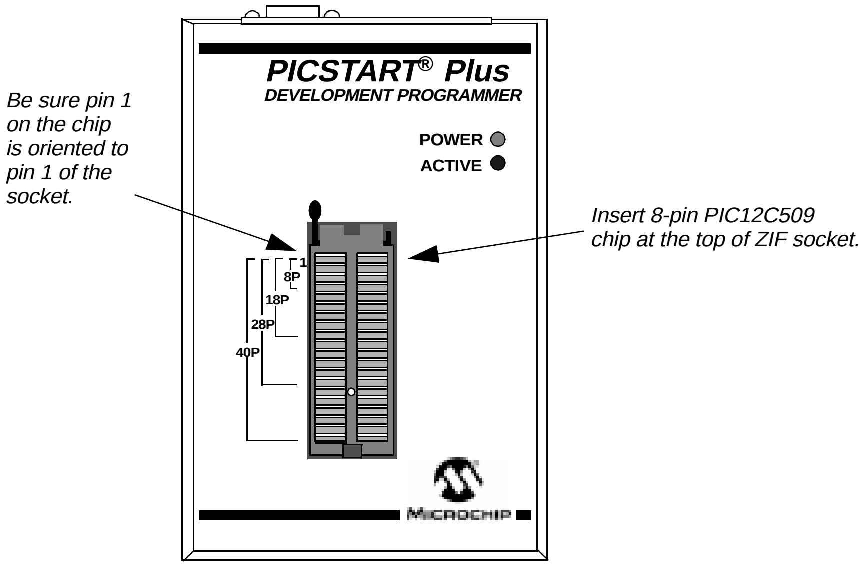
4. The *Program Memory Window* shows the actual opcodes and where they will go in the microcontroller’s program code space. You can change the display format by clicking on the “Document” icon in the upper left-hand corner of the program memory window and selecting Hex Code, Machine Code or Disassembly Display.



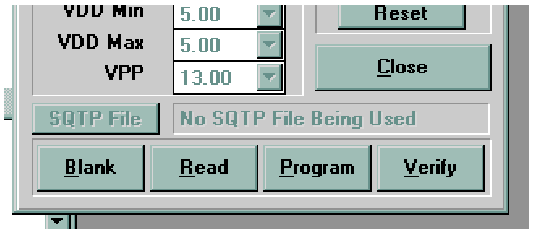
5. You are now ready to program the PIC12C509 microcontroller. At this time, you should familiarize yourself with the correct orientation of the PIC12C509 part with respect to Pin 1 and the Zero Insertion Force (ZIF) socket on the PICSTART Plus Programmer. The chip has a notch at one end – designating pin one.

   Once you have determined the correct orientation of the microcontroller, move the ZIF lever on the PICSTART Plus until the contacts open fully. The chip should be placed into the programmer ZIF socket at the top, with the notch oriented up.

   Carefully place the PIC12C509 part into the programming socket of the PICSTART Plus Programmer. Once the part is seated, move the lever to the closed position. This will firmly clamp the microcontroller pins and allow the part to be programmed.

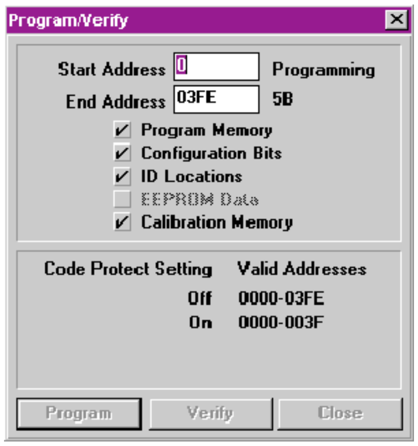

Be sure pin 1 on the chip is oriented to pin 1 of the socket.
PICSTART® Plus
DEVELOPMENT PROGRAMMER
POWER
ACTIVE
Insert 8-pin PIC12C509 chip at the top of ZIF socket.
1
8P
18P
28P
40P
MICROCHIP

6. To program the part, click on the **Program** button at the bottom of the *PICSTART Plus Device Programmer* window.



VDD Min 5.00
VDD Max 5.00
VPP 13.00
No SQTP File Being Used

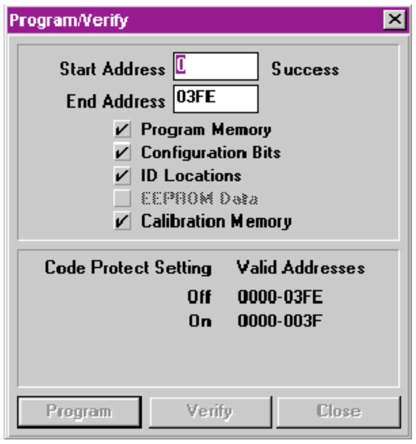
7. The *Program/Verify* window appears showing the status of the programming cycle.



Start Address 0 Programming
End Address 03FE 5B
✓ Program Memory
✓ Configuration Bits
✓ ID Locations
☐ EEPROM Data
✓ Calibration Memory

Code Protect Setting	Valid Addresses
Off	0000-03FE
On	0000-003F

8. The programming cycle should take a few seconds. After completion, the *Program/Verify* window will indicate that a successful programming session has been completed.



Start Address 0 Success
End Address 03FE
✓ Program Memory
✓ Configuration Bits
✓ ID Locations
☐ EEPROM Data
✓ Calibration Memory

Code Protect Setting	Valid Addresses
Off	0000-03FE
On	0000-003F

9. Once the microcontroller has been successfully programmed, remove it from the PICSTART Plus Programmer. You are now ready to insert the device into the "Pong Board." The "Pong Board" schematic is located in Appendix A.2.

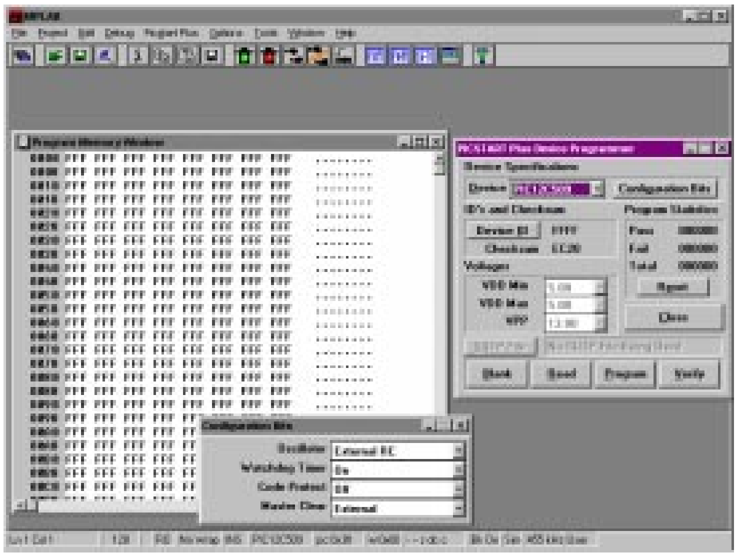
   Notice that the IC socket on the Pong Board also has a notch in it to help you locate Pin 1. When inserting the programmed chip into the socket, use care not to damage the pins as you push the chip into place.

   The program you have just completed will cause the Pong Board to respond by lighting the right LED if the right key or both keys are pressed. The left LED will light up if the left button is pressed. Otherwise, the board will go into a lower power SLEEP mode to conserve battery life.

Appendix A. Programming a PIC12C509 MCU with the 8-pin Pong Game

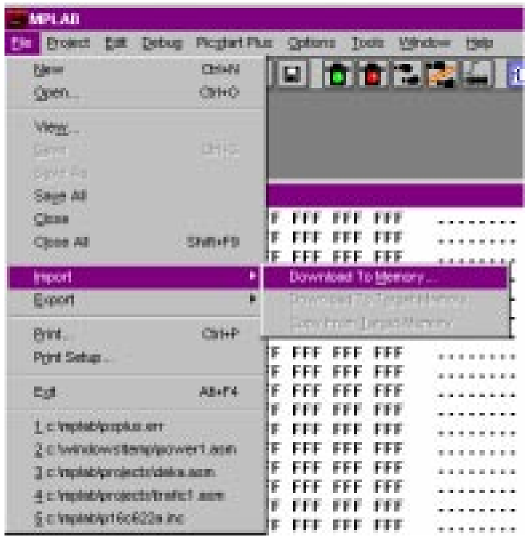
You have successfully completed this tutorial, and would now like to do more with the Pong board[1] provided. A programming file, called 8pinpong.hex[2] has been provided on the floppy disk accompanying this tutorial. With this file, you can program another PIC12C509, put it in the board, and play the Pong game. It is assumed that you have successfully completed the tutorial provided. We will therefore provide an abbreviated explanation on how to program the part for the Pong game.

1. Close the open project if you have not already done so. No project is necessary for programming a part when the hex file is already provided. Enable the PICSTART Plus programmer, and select the PIC12C509. Open the *Program Memory* window (*Window>Program Memory*). Your screen should look like this:

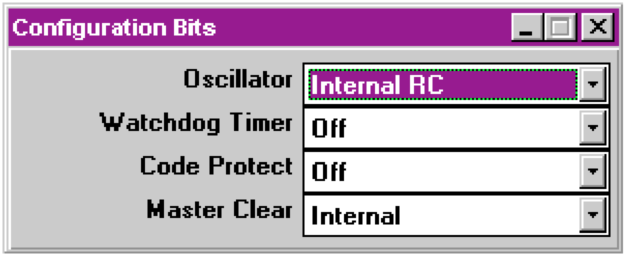


1. If you are using this tutorial separately from the kit that the Pong board is included in, you can create your own using the schematic in Section A.2.
2. The 8-pin Pong .hex file is also available for download from www.microchip.com.

2. To change the display mode of the Program Memory window, click on its upper left corner (at the document icon) and select Hex Code, Machine Code, or Disassembly Display. We have selected Disassembly Display here.
3. To load the programming file into memory, select *File>Import>Download to Memory*, as shown below. Locate the file 8pinpong.hex from the floppy disk provided (or on your hard drive if you have copied it over) and select **OK**. You should see the program memory window change to reflect the loaded program.



4. Make sure that the Configuration Word options (refer to “About the Demonstration Program” section for more details) shown in the *PICSTART Plus* window under *Device Specifications* are set as shown:



Configuration Bits

Oscillator	Internal RC
Watchdog Timer	Off
Code Protect	Off
Master Clear	Internal

5. Click the **Program** button. If the programming process was successful, you can now place the programmed part into the Pong Board, and you are ready to play.

A.1 HOW TO PLAY THE 8-PIN PONG GAME

8-pin Pong is a one dimensional version of the original video game played on the 8 LEDs across the top of the board. Each player takes a button at each end of the board. The object is to press the button when the “ball” is at the end of the board. Pressing the button when the ball is at the end returns the ball to the other player. Swing too early or too late and the ball is missed. Winner serves; one point per play; the first player to reach 15 points wins.

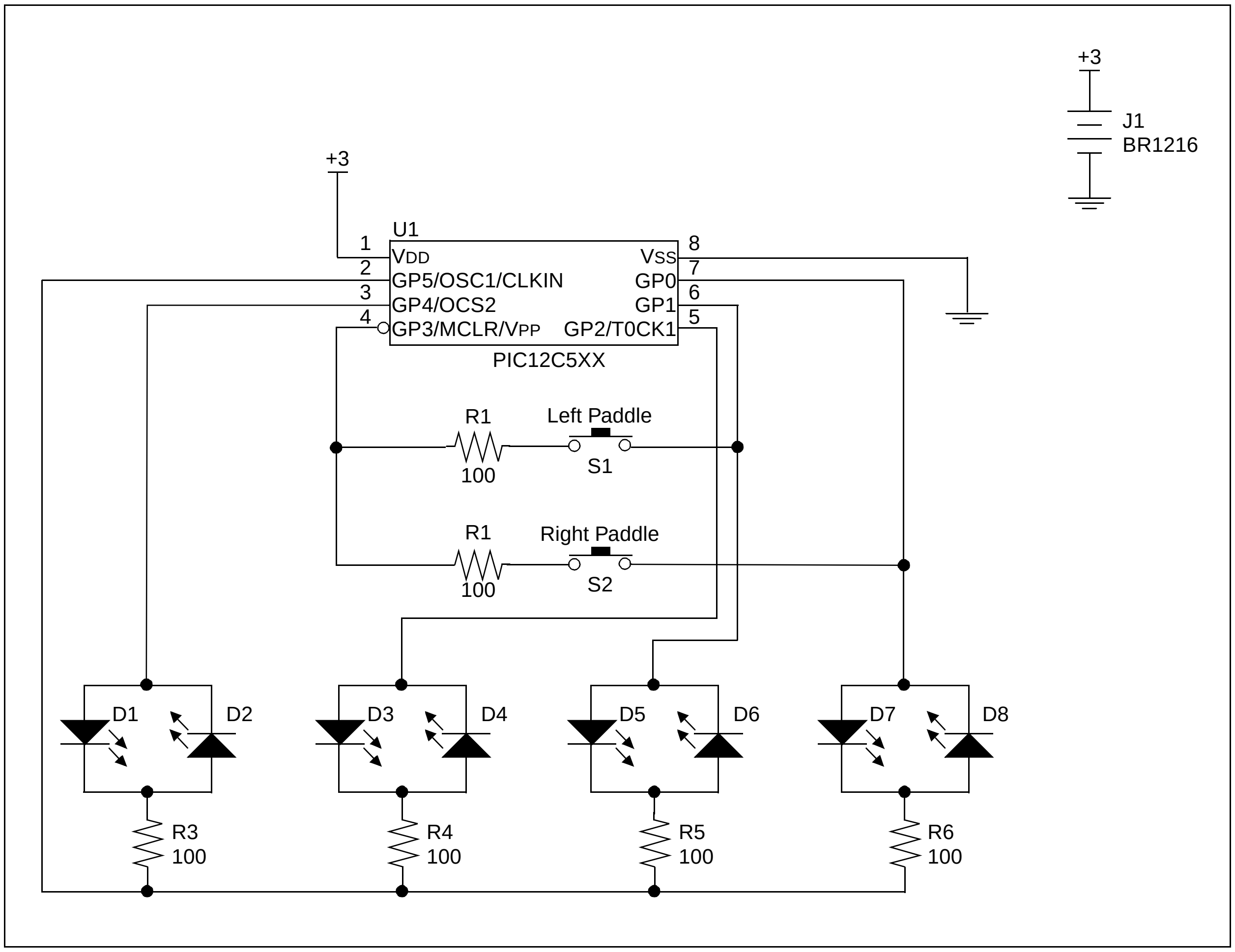
The game begins with one of the right-most LED flashing, awaiting the serve. The ball is served when the corresponding button is pressed. The ball then moves down the board to the other end. The other player must hit the ball when it gets to the last LED in order to return the ball. Play continues until a player misses the ball. A miss occurs when the ball is not in the last LED. When the ball is hit just right, the ball takes off with a high speed return and the game shifts into high gear.

The score is displayed in binary format between plays for a second or two. The left player's score is displayed on the left side of the board and right player's score on the right side. The game is to 15 points, and the winning score is flashed on the screen.

The game resets when both players press their buttons simultaneously.

The Pong game shuts itself off after 30 seconds of inactivity. Wake-up occurs when either button is pressed.

A.2 8-PIN PONG BOARD SCHEMATIC



Appendix B. How to Get Help and Recommended Reading

This tutorial is by no means exhaustive. Important subjects not covered here include writing relocatable programs to be assembled to object files, linking object files, device specifications, complete instruction definitions, applications specific information, and much more.

If you are interested in continuing your familiarization with Microchip’s products and development tools, there are a number of items available to you for this purpose. You will find the literature listed in this section on the Microchip CD-ROM and on the web site at www.microchip.com. Hard copies of most literature can be obtained from your local Microchip distributor or representative.

If you are interested in obtaining pricing, delivery, samples, literature or any other information, please contact the distributor or factory representative nearest you. A complete listing of these sales offices can be found on the CD-ROM, the web site, and in the back of any Microchip product literature.

B.1 OTHER USEFUL LITERATURE FROM MICROCHIP

Datasheets for all Microchip PICmicro products are available. The datasheets include device specifications, description of device operation, instruction definitions, product ordering guides and more. Product datasheets can be found on the CD-ROM and the web site.

The Embedded Control Handbook, Volume I (DS00092) ***and II*** (DS00167)***.*** These books contain a complete collection of the Application Notes provided by Microchip to help you design your product. There are many introductory as well as advanced topics covered. Program examples are provided. These application notes can also be found on the CD-ROM and the web site.

The Mid-Range PICmicro MCU Reference Manual (DS33023)***.*** A guide to using the Microchip Mid-Range family and its peripherals. This is an extensive how to guide and a “must have” for anyone developing for the PIC16CXXX MCU family.

MPLAB Tutorial

MPLAB IDE, Simulator, and Editor User’s Guide (DS51025)

MPASM User’s Guide with MPLINK and MPLIB (DS33014)

PICSTART Plus User’s Guide (DS51028)

There are extensive Help files installed with MPLAB, and found in the MPLAB Program Group in windows. Some of these files are actually complete electronic versions of the User's Guides. Subjects include MPLAB, MPASM, MPLAB-SIM and PICSTART Plus.

Device Errata documents are available from the web site under Datasheets. In these documents Microchip provides the latest device errata and workarounds.

The latest version of MPLAB and its components can always be found on the Microchip web site at: www.microchip.com.

B.1.1 Additional Resources - Beginning Level

Easy PIC'n (English)
David Benson/Square 1 Electronics
Phone: 707-279-8881 (US)
ISBN: 0-9654162-0-8

A Beginners Guide to the Microchip PIC (English)
Nigel Gardner/ Bluebird Technical Press Ltd.
Phone: 800 718 1997 (US), +44 1536 201 201 (UK)
ISBN: 1-899013-01-6, Stock No: 07WX4611

PIC Cookbook Volume 1 (English)
Nigel Gardner/Peter Birnie/Bluebird Technical Press Ltd.
Phone: 800 718 1997 (US), +113 2636311 (UK)
ISBN: 1-899013-02-4, Stock No: 07WX4610

PIC Cookbook Volume 2 (English)
Nigel Gardner/Peter Birnie/Bluebird Technical Press Ltd.
Phone: 800 718 1997 (US), +113 2636311 (UK)
ISBN: 1-901631-00-1, Stock No: 46WX3136

The Greatest Little PIC Book (English)
Gordon Mcnee/Bluebird Technical Press Ltd.
Phone: 800 718 1997 (US), +113 2636311 (UK)
ISBN: 1-901631-01-X

Getting Started with PIC Microcontrollers (English)
Al Stevens/Ziggurat Technologies
Phone: ++ 27 11 7922187 (South Africa)
ziggurat@global.co.za

PIC16C5X Introductory Course (English)
Farsoft Computers cc
Phone: ++ 27 11 8289255 (South Africa)
farsoft@surfnet.co.za

B.1.2 Additional Resources - Intermediate Level

Programming and Customizing the PIC Microcontroller (English)
Myke Predko/McGraw-Hill
ISBN: 0-07-913646-X

PIC'n Up The Pace (English)
David Benson/Square 1 Electronics
Phone: 707-279-8881 (US)
ISBN: 0-9654162-1-6

PIC's in Practice (English)
Francesco Volpe/Safinaz Volpe/Elektor Electronics
ISBN: 0-905705-51-3

Les Microcontrolleurs PIC et mise en oeuvre (French)
Christian Tavernier/Dunod
Fax: +33 1 46 347 846 (France)
ISBN: 2-10-002647-X

Micontrolleurs PIC a structure RISC (French)
C.F. Urbain/Publitronic
Fax: +33 1 20 486 964 (France)
ISBN: 2-86661-058-X

Pratique des Microcontroleurs PIC (French)
Francesco Volpe/Safinaz Volpe/Publitronic Elektor
ISBN: 2-86661-077-6

Mit dem PIC-Controller Erfolgreich Arbeiten (German)
Dr Anne Koenig/Manfred Koenig/Markt & Technik Verlag
Phone: 89 460 030 (Germany)
ISBN: 3-8272-5168-0

Mikrokontroller mit RISC Struktur (German)
C.F Urbain/ Elektor Compact
ISBN: 3-928051-83-0

PIC uC Praxis (German)
Francesco Volpe/Safinaz Volpe/Elektor Verlag
ISBN: 3-89576-030-7

La Programmazione dei Microcontrollori PIC (Italian)
Andrea Sbrana
Phone: +39 544 464070 (Italy)

New Possibilities with the Microchip PIC (Russian)
RIGA
Phone: +371 935 0550 (Latvia)

MicroControladores PIC (Spanish)
Christian Tavernier/Paraninfo
Phone: 446-3350 (Spain)
ISBN: 84-283-2373-9

Appendix C. Correcting PICSTART® Plus Communications Problems

The large majority of the time everything goes well. If you are experiencing any problems getting PICSTART® Plus to communicate, there are a few things you can do.

1. The current version of PICSTART Plus does not work under Windows® NT. NT requires a special hardware driver that is not currently available from Microchip, but is planned for a future release.
2. Make sure that the programmer has power and that the serial cable is connected correctly.
3. Ensure that there are no conflicts with other devices. This often happens when you have a modem or other serial device that is improperly configured. If you believe you are experiencing this problem, consult your Windows manual or other reference literature. You can try removing, reconfiguring or disabling the conflicting device, but do so only if you are familiar with these tasks.
4. Try connecting the PICSTART Plus to a different serial port. If your PC has a 25-pin serial port, you will need a 25- to 9-pin serial port adapter.
5. On some systems errors occur because of driver and hardware incompatibility. Try changing Flow Control to Hardware and/or turning off the FIFO for the serial port. In Windows 95 this is done in the Control Panel. Click the System icon. Next, select the Device Manager tab, and select Ports. (Note, this is also where you would look for conflicts) If necessary, expand the Ports selection by clicking the “+” sign next to it. Now double click on the I/O port that PICSTART Plus is connected to. Select the Port Settings tab. This is where flow control can be set to Hardware. To turn off the FIFO, click the Advanced button. Deselect the Use FIFO box and click **OK** to save.
6. If you have a COM port but MPLAB will not let you select it (the option is grayed out) you may be able to assign the port manually by editing the mplab.ini file. Typically, this occurs if you have an “opening” in your COM port list. (i.e., you have a COM1, COM2, and a COM4, but no COM3). In this case you may be able to fix it by opening mplab.ini (use the Microsoft® Windows® FIND command to locate this file) and editing the section called [programmers] so that the setting `CommPort=1` is set to the port you want selected. This is just a work-around to a deeper problem in which windows is incorrectly reporting port availability through the 16-bit driver.

NOTES:

Appendix D. Glossary

To provide a common frame of reference, this Glossary defines the terms that follow.

Application

A set of software and hardware developed by the user, usually designed to be a product controlled by a PICmicro microcontroller (MCU).

Assembler Source Code

A text file that is processed by an assembler to produce a one-to-one correspondence between assembler instructions and PICmicro machine code.

Asynchronous Stimulus

Data generated in real-time by the user to simulate external inputs to the simulator.

Breakpoint

An address where real-time execution of the firmware loaded in program memory will halt.

Build

A function that recompiles all the source files for an application.

C Code

A program written in the high level language called “C,” and which will be converted into PICmicro machine code.

Caution

An alert that is provided to warn you of a situation that would cause physical damage to a device, software file, or equipment.

Compile

To translate a user’s “C” source text code into machine code.

Configuration Bits

Unique bits programmed to set modes of operation. A configuration bit may or may not be preprogrammed.

Data RAM

General purpose file registers from RAM on the PICmicro device being emulated. The File Register window displays data RAM.

Dynamic Data Exchange (DDE)

The message protocol in Microsoft Windows that transfers information in real-time between windows applications. MPLAB acts as a DDE client that can transmit data to requesting applications, but cannot receive data from other applications.

EEPROM

Electrically Erasable Programmable Read Only Memory.

Emulation

The process of executing software loaded in the PICMASTER program memory on the emulator probe as if the firmware resided on the microcontroller device under development.

Emulation Memory

Program memory contained within the emulator.

Emulator

Hardware that performs emulation. *See Emulation*.

Emulator System

The Microchip Emulator System includes the PICMASTER Pod, the PC Interface Card, a Probe Kit, PRO MATE Device Programmer, Demonstration Board, Socket Module and the MPLAB Software.

Export

Send data out of MPLAB in a standardized format.

Extended Microcontroller Mode (PIC17CXXX Devices Only)

In extended microcontroller mode, on-chip program memory as well as external memory is available. Execution automatically switches to external if the program memory address is greater than the internal memory space of the PIC17CXXX device. Inaccessible memory in extended microcontroller mode includes fuses, test memory, and boot memory.

External RAM

Off-chip Read/Write memory.

File Registers

On-chip general purpose and special function registers.

Halt

The command that stops the emulator. Executing Halt is the same as stopping at a breakpoint. The program counter stops, and the user can inspect and change register values, and single step through code.

Hex Code

A file of executable instructions assembled or compiled from source code into standard hex format code. Hex code can be directly converted to object code.

High Level Language

A language for writing programs that is of a higher level of abstraction from the processor than assembler code. High level languages employ a compiler to translate statements into machine instructions that the target processor can execute.

IDE

Integrated Development Environment. An application that has multiple functions for software development. The MPLAB IDE integrates a compiler, an assembler, a project manager, an editor, a debugger, simulator, and an assortment of other tools within one Windows 3.1 application. A user developing an application should be able to write code, compile, debug and test an application without leaving the MPLAB desktop.

Import

Bring data into the MPLAB Integrated Development Environment (IDE) from an outside source

Logic Probes

Up to fourteen logic probes connect to the Emulator. The logic probes provide external trace inputs, external trace halt signal, trigger output signal, external break input signal, trace buffer clock, +5V, and a common ground.

Make Project

A command that rebuilds an application, re-compiling only those source files that have changed since the last complete compilation.

Microcontroller Mode

One of the possible program memory configurations of the PIC17CXXX family of microcontrollers. In microcontroller mode, only internal execution is allowed. Thus, only the on-chip program memory is available in microcontroller mode. Accessible memory includes: program memory, fuses, test memory and boot memory (FE00h to FFFFh).

Microprocessor Mode

One of the possible program memory configurations of the PIC17CXXX family of microcontrollers. In microprocessor mode, the on-chip program memory is not used. The entire 64K program memory is mapped externally. Inaccessible memory in microprocessor mode includes fuses, test memory, and boot memory.

MPLAB Software

The name of the main executable program that supports the IDE with an Editor, Project Manager, and Emulator/Simulator Debugger. The MPLAB Software resides on the PC host. The executable file name is MPLAB.EXE. MPLAB.EXE calls many other files.

MRU

Most Recently Used. Refers to files and windows available to be selected from MPLAB main pull down menus.

Object Code

The machine code that is produced from the source code after it is processed by an assembler or compiler. This code will be-the memory-resident code that will run on the PICmicro MCU in the user's application.

Off-Chip Memory

Off-chip memory refers to the memory selection option for the PIC17CXXX device where memory may reside on the target board, or where all program memory may be supplied by the Emulator. *Options>Processor Setup>Hardware* provides the Off-Chip Memory selection dialog box.

Pass Counter

A counter that decrements each time an event (such as the execution of an instruction at a particular address) occurs. When the pass count value reaches zero, MPLAB halts the processor. You can assign the Pass Counter to either break logic or to trace logic.

PC

Any IBM or compatible Personal Computer. MPLAB needs a 386 or better machine.

PC Host

The computer running Windows 3.x.

PC Interface Card

A Microchip proprietary parallel interface card allowing the MPLAB software residing on the PC to communicate with the PICMASTER emulator.

PICMASTER

The hardware unit that provides tools for emulating and debugging firmware applications and is also referred to as the Emulator, and PICMASTER. This unit contains Emulation memory, breakpoint logic, counters, timers, and a trace analyzer among some of its tools.

PICmicro

PICmicro refers to the PIC12CXXX, PIC16CXXX, and PIC17CXXX Microchip microcontroller families.

Pod

The external emulator box that contains emulation memory, trace memory, event and cycle timers, and trace/breakpoint logic. Occasionally used as an abbreviated name for the PICMASTER Universal In-Circuit Emulator.

Power on Reset Emulation

A software randomization process that writes random values in data RAM areas to simulate uninitialized values in RAM upon initial power application.

Probe

A device specific interface between the simulator and the target application. The probe connects to the emulator via a ribbon cable, and the target application board connects to the probe via a ribbon cable. The probe is sometimes called the header board.

Program Counter

A register that specifies the current execution address.

Program Memory

Memory in the emulator containing the downloaded target application firmware.

Project

A set of source files to build the object code for an application.

Prototype System

A term referring to a user's target application, or target board.

Radix

The number base, hex, or decimal, used in selecting an address and for entering data in the *Window > Modify* command.

Run

The command that releases the emulator from halt, allowing it to run the application code and change or respond to I/O in real time.

SFR

Special Function Registers.

Simulator

A software program that models the operation of the PICmicro microprocessor.

Simulator Stimulus

Data generated to exercise the response of simulation to external signals. Often the data is put into the form of a list of actions in a text file.

Single Step

This command steps though code, one instruction at a time. After each instruction, MPLAB updates register windows, watch variables, and status displays so you can analyze and debug instruction execution.

You can also single step C compiler source code, but instead of executing single instructions, MPLAB will execute all assembly level instructions generated by the line of the high level C statement.

Source

Source code, usually a text file of assembly instructions or C code.

Special Function Registers

Registers that control I/O processor functions, I/O status, timers, or other modes or peripherals.

Stack

“Push-Down” list of calling routines. Each time a PICmicro microcontroller executes a call, the software pushes the return address to the stack. A RET or RETLW command pops the address from the stack.

Static RAM, or SRAM

Static Random Access Memory. Program memory you can Read/Write on the target board that does not need refreshing frequently.

Step-Into

This command is the same as Single Step. Step-Into (as opposed to Step-Over) follows a CALL instruction into a subroutine.

Step-Over

Step-Over allows you to debug code without stepping into subroutines. When stepping over a CALL instruction, the next breakpoint will be set at the instruction after the CALL. If for some reason, the subroutine gets into an endless loop or does not return properly, the next breakpoint will never be reached.

The Step-Over command is similar to Single Step except for its handling of CALL instructions.

Stopwatch

A 48-bit counter for measuring execution cycles.

Symbol

An label usually produced by an assembler or compiler that refers to machine locations by function names, variable locations, constant declarations, source line-number, or other reference to user source code.

System Button

The System Button is located in the upper left corner of Windows and some dialogs. This button usually has “Minimize”, “Maximize”, and “Close.” In some MPLAB windows, additional modes or functions can be found under the System Button.

Target

Refers to a user application.

Target Application

Firmware residing on the target board.

Target Board

The circuitry and programmable device that makes up the target application.

Target Processor

The microcontroller device on the target application board that is being emulated or simulated.

Template

Lines of text that you build for inserting into your files at a later time. The MPLAB Editor stores templates in template files.

Tool Bar

A row or column of icons that you can click on to execute MPLAB functions.

Trace

An emulator or simulator function that logs program execution in real-time.

Trigger Output

Trigger output refers to an output signal that can be generated at any address or address range, and is independent of the trace, arm, and breakpoint settings. Any number of trigger output points can be set. The trigger output signal is available on logic probe pin 13 (white probe tip).

Watchdog Timer

A timer on a PICmicro microcontroller that resets the processor after a selectable length of time.

Watch Variable

A variable that you may monitor during a debugging session. Watch windows contain a list of watch variables that are updated at each breakpoint.

NOTES:

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